

Multi Mission Observation Operator(M₂O₂)

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Background

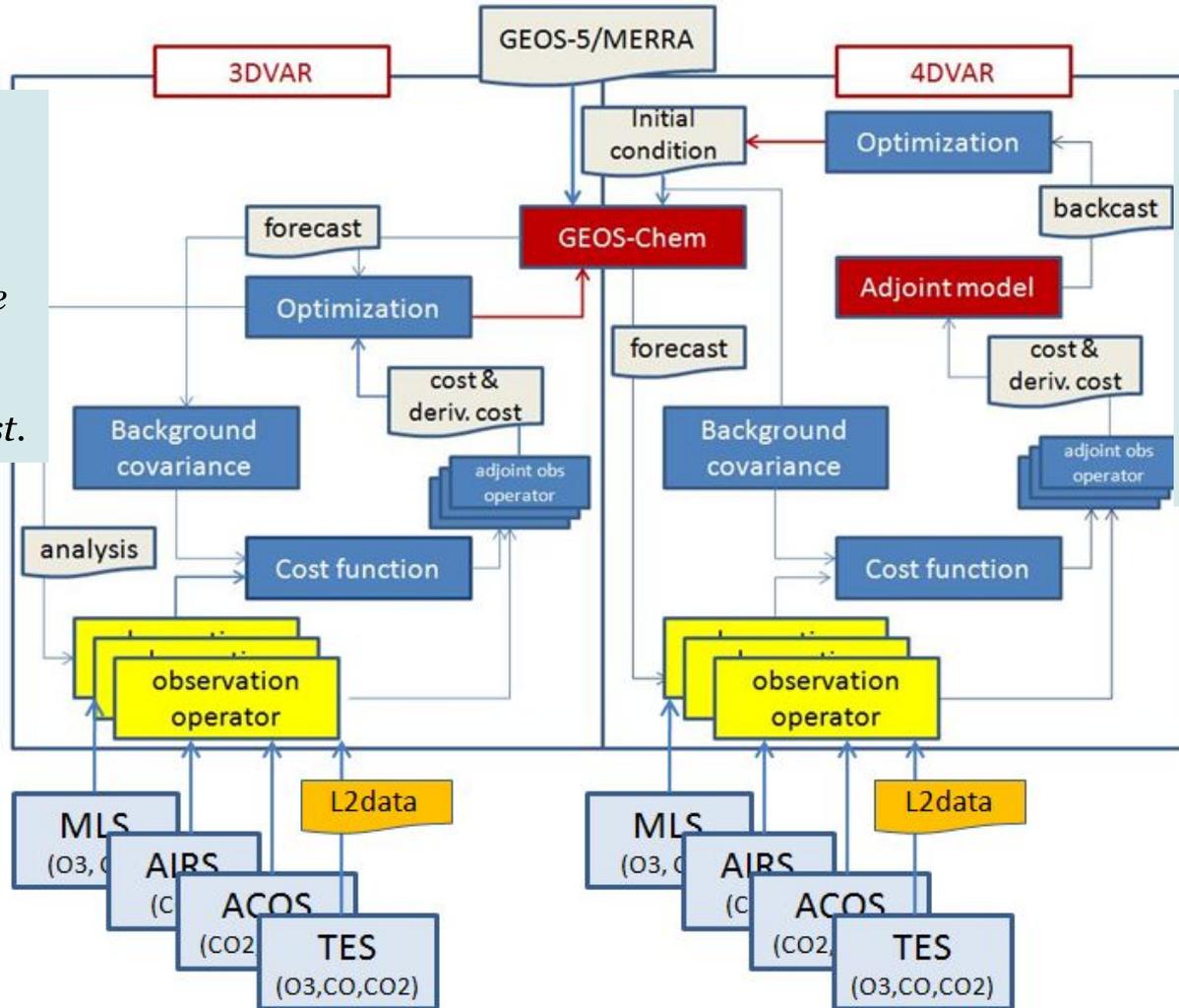
Observation includes coordinate information (sample time, sample location, vertical grid) and retrieved state information (observed state, a priori, averaging kernel, and observation uncertainty).

	Algorithm	variables
Cost function	$J(x) = J_{\text{obs}}(x)/2 + J_{\text{bg}}(x)/2$	X: state vector
Observation force	$J_{\text{obs}}(x) = (y - H(x)) R^{-1} (y - H(x))^T$	y : observed state R : obs. uncertainty
Model (background) force	$J_{\text{bg}}(x) = (x - x_b) B^{-1} (x - x_b)^T$	x _b : background state B : model uncertainty
Observation operator	$H(x) = A(x - y_a) + y_a$	y _a : a priori A : averaging kernel
Adjoint cost	$dJ(x) = A^T (y - H'(x)) R^{-1}$	



Current Implementation

The cost and adjoint cost are computed per simulation time step to assimilate observations. Optimization improves forecast.



The cost and adjoint cost are integrated over the entire assimilation period. Optimization improves initial condition.



Problem statement

The L2 products are organized differently from mission to mission. Each mission has a unique file structure optimized for mission-specific use. Some missions organize them per orbit, some per day. Some missions include ancillary information in one file, some in separate files.

The L2 products use various quality control indicators. Most level-2 products provide a quality field that varies from on/off flag to multi-level grading from 'bad' to 'good'. Some missions provide only the diagonal vector of the uncertainty error covariance matrix, while others provide the entire content.

The L2 products are voluminous with detailed information on sampling geometry, observation condition, instrument property, and retrieval analysis. During the data assimilation process, only a subset of the L2 data is used.

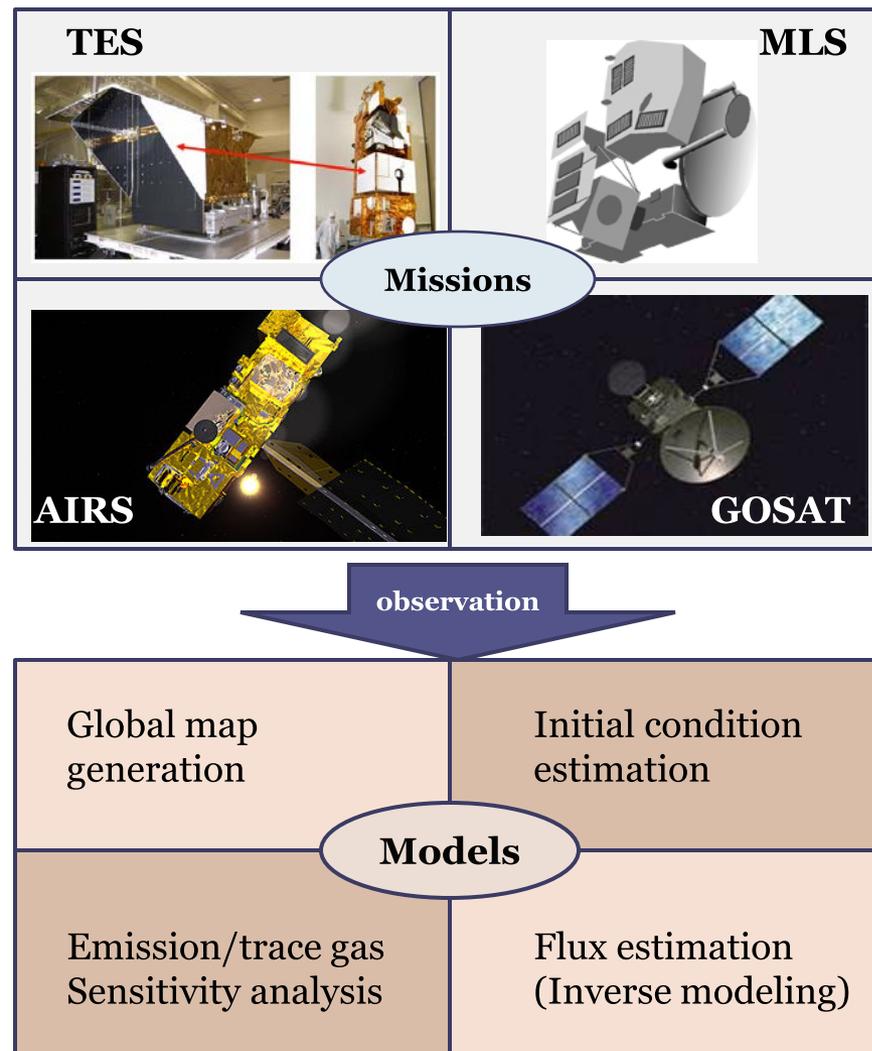
The L2 products require additional quality screening. The retrieval result may be invalid even after the retrieval process passed the quality control gate when the observing condition at the time of data acquisition was such that the instrument system introduced unacceptable noise (very low signal-to-noise ratio). The impact of noise varies across the spectral range requiring an additional quality filter per retrieved state variable.

The L2 products are moving target. The retrieval process of an atmospheric state variable from a remote atmospheric sounding system is a complicated estimation process involving a wide range of ancillary data products. Consequently, the retrieval process must be repeated when the ancillary data products have been revised and a new version of the data products must be released.



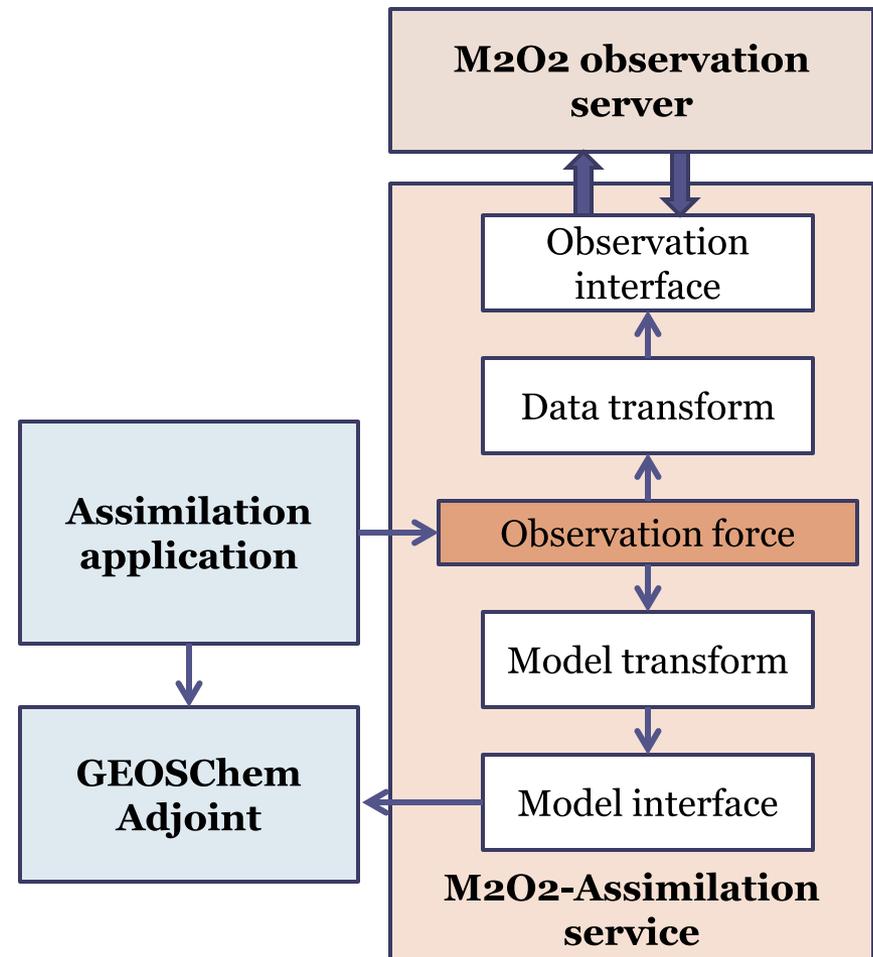
Key Objectives

- Create a streamlined interface mechanism between the atmospheric chemistry model developers and the atmospheric science mission data providers.
- Install a sustainable observation service that prepares assimilation-relevant datasets (L2# data) from the level-2 data products of atmospheric science missions (TES, MLS, AIRS, and GOSAT).
- Deliver a unified observation assimilation service to NASA atmospheric chemistry modeling community that can assimilate atmospheric component observations (O₃, CO, CO₂, CH₄) from multiple missions.



Approach

- Develop a “M2O2-observation server” employing the simple subset wizard (SSW) webservice at GES DISC for “on-demand” L2# data generation and transfer (quality filtered NetCDF files of assimilation-relevant data fields organized for each day).
- Develop a “M2O2-assimilation service” module composed of a set of functions for interfacing with the M2O2-observation service to request/download L2# data, and with GEOSChem-Adjoint system to perform observation and model force computation.
- Develop 3D-var and 4D-var assimilation applications and generate science products to validate technical readiness level (TRL) of the M2O2-observation service and M2O2-assimilation service.



M2O2 Solutions

The L2 products are organized differently from mission to mission. Each mission has a unique file structure optimized for mission-specific use. Some missions organize them per orbit, some per day. Some missions include ancillary information in one file, some in separate files.

Generate a mission-generic L2# data organized in a daily interval.

The L2 products use various quality control indicators. Most level-2 products provide a quality field that varies from on/off flag to multi-level grading from 'bad' to 'good'. Some missions provide only coverage, while others provide the entire content.

Provide a unified observation data structure.

The L2 products are voluminous with detailed information on sampling geometry, observation condition, instrument property, and retrieval analysis. During the data assimilation process, only a subset of the L2 data is used.

Extract only assimilation-relevant data fields.

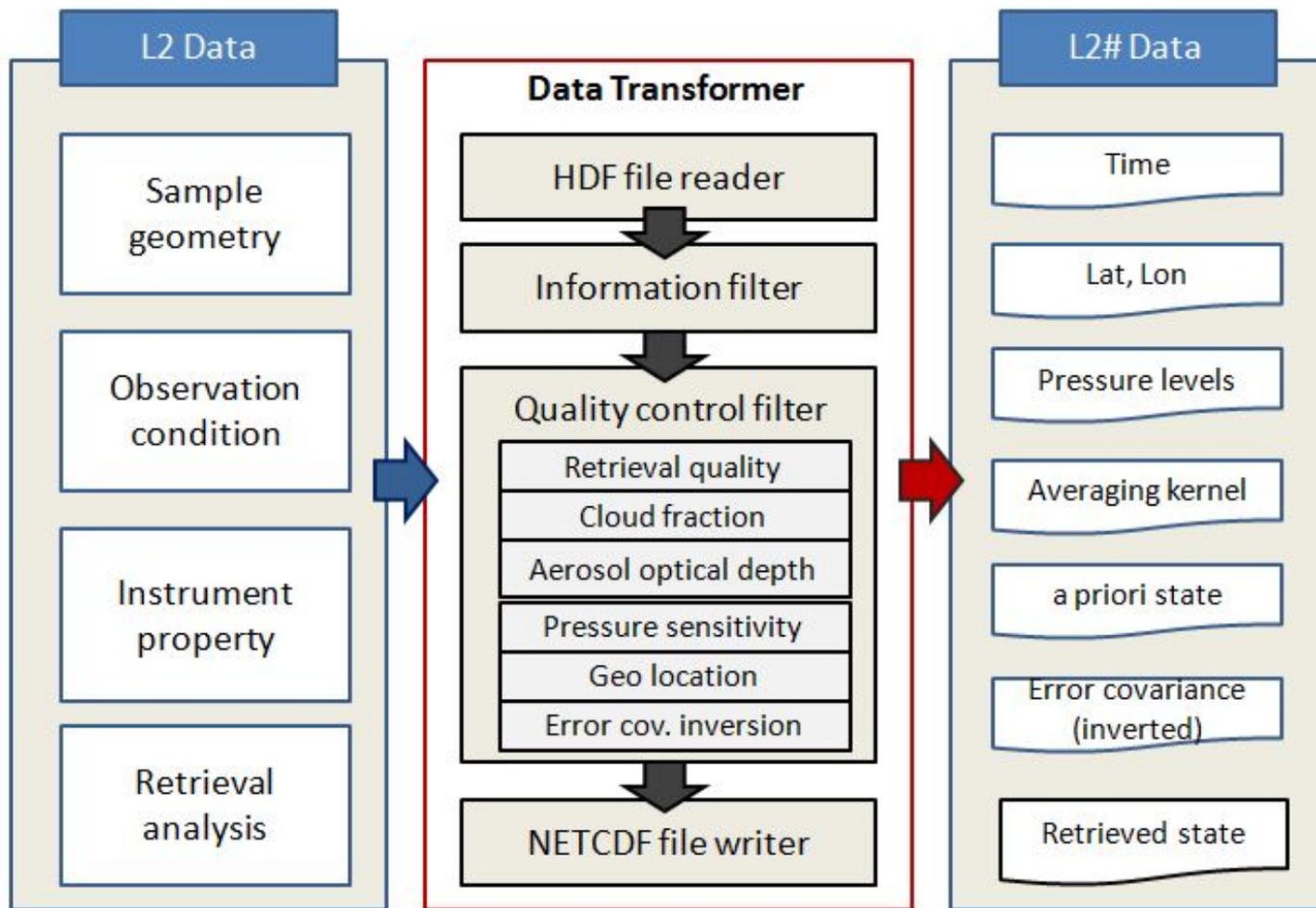
The L2 products require additional quality screening. The retrieval result may be invalid even after the retrieval process passed the quality control gate when the observing condition at the time of data acquisition was such that the instrument system produced unacceptable noise (very low signal-to-noise ratio). The impact of noise varies across the spectral range requiring an additional quality filter per retrieved state variable.

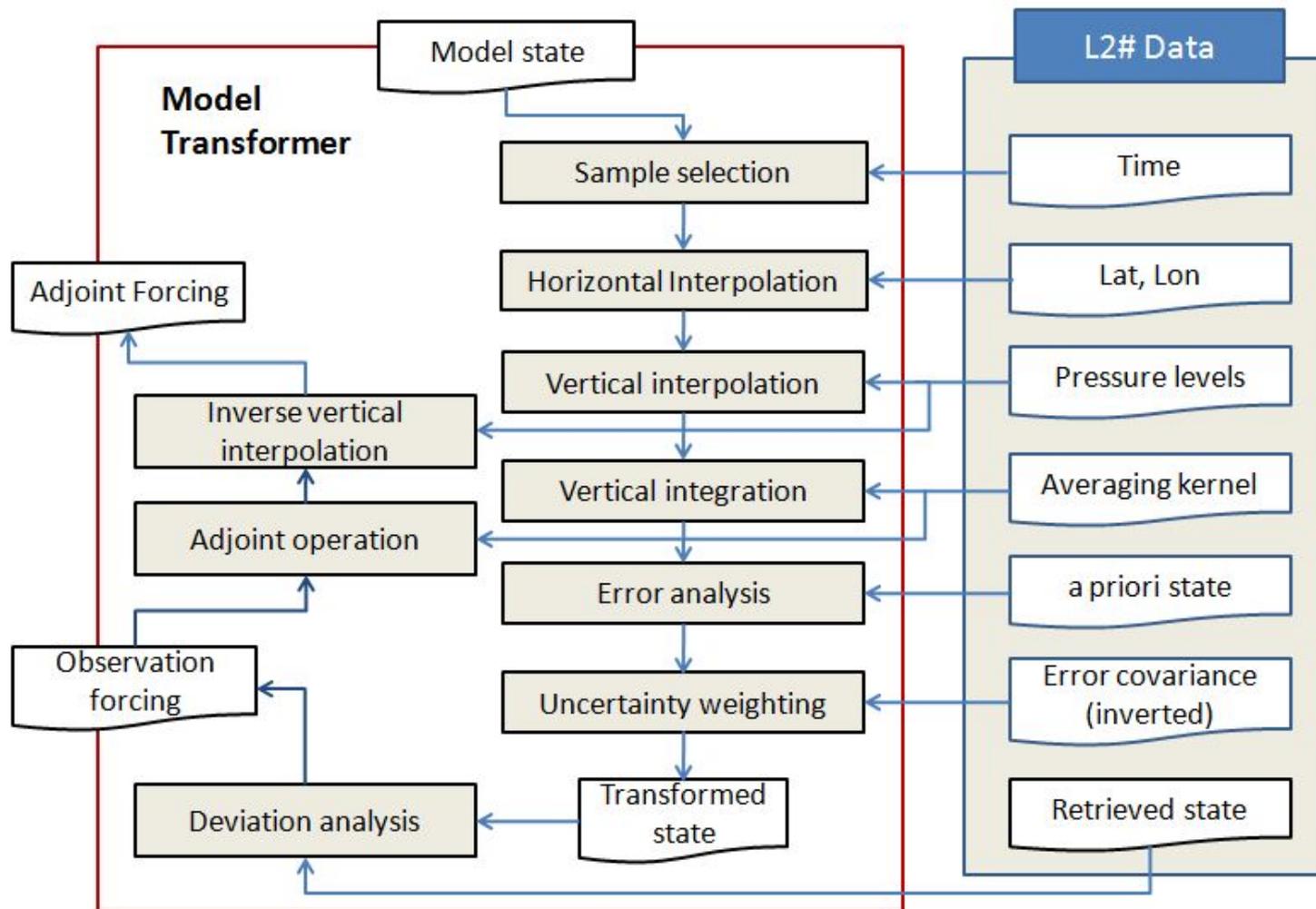
Automatically perform a comprehensive quality control.

The L2 products are moving target. The retrieval process of an atmospheric state variable from a remote atmospheric sounding system is a complicated estimation process involving a wide range of ancillary data. If the ancillary data, the retrieval process must be repeated when the ancillary data products have been revised and a new version of the data products must be released.

Continuously track the Level-2 data product versions.

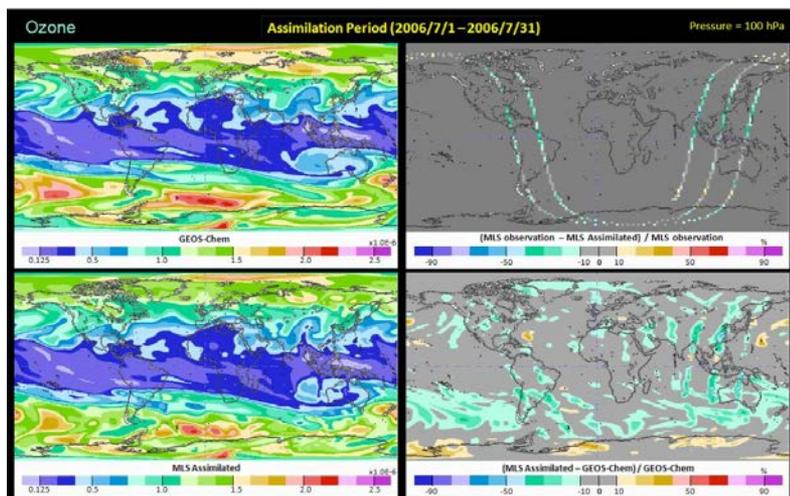




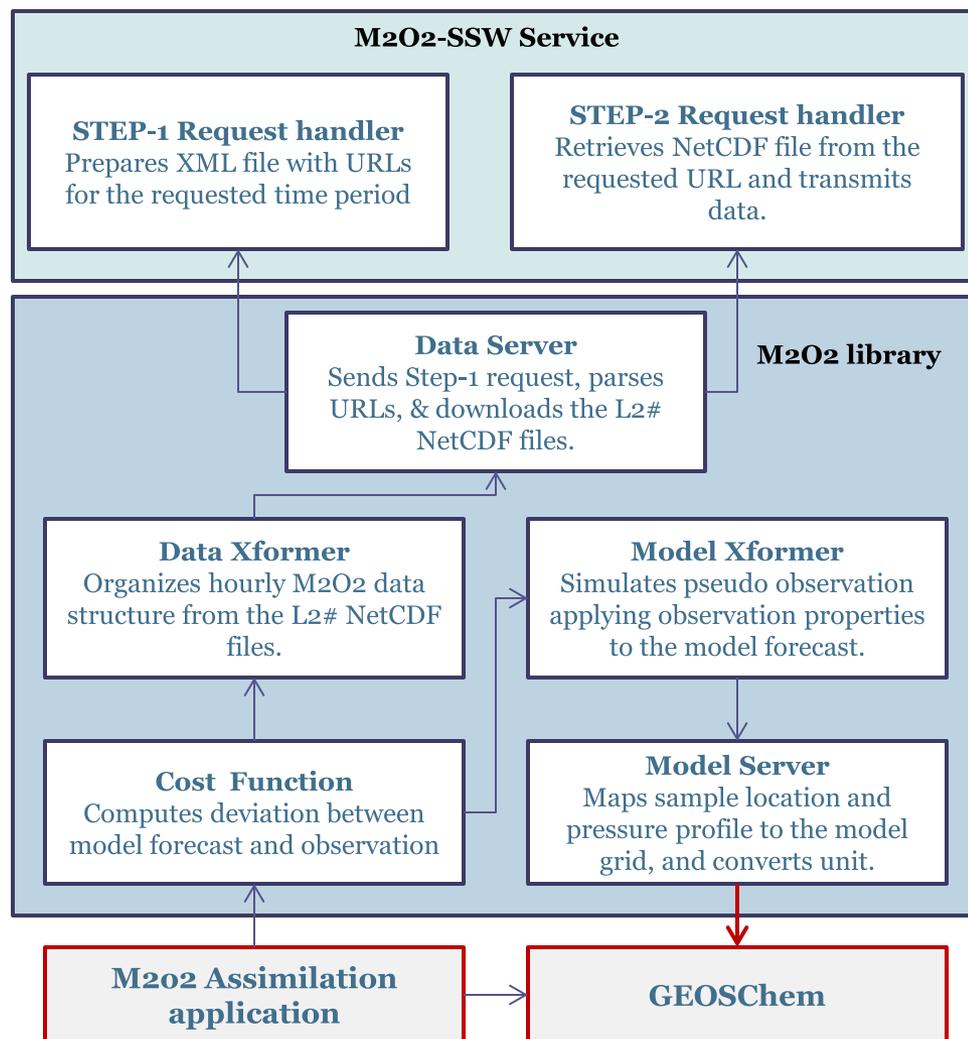


Current status

- M2O2-Simple Subset Wizard (SSW) service is operational 24/7 serving Step-1 and Step-2 requests.
- Functional test of M2O2-software library has been completed for model server, model transformer, data server, and data transformer.
- Beta-site for M2O2-MLS O₃ assimilation service has been installed for GEOSChem-Adjoint working group.



MLS-O₃ 3DVAR assimilation



Significance

- Unified satellite observation information service (data availability reporting, quality filtering, data field extraction, and file format conversion) removes custom software development requirement.
- Linkable assimilation service software module supporting 3D and 4D variational assimilation applications enables heterogeneous model collaboration.
- Observation service and the assimilation service collectively enable simultaneous assimilation of observations from multiple missions.

