OMSO2 Release Specific Information

Software Version

The current release of collection 3 OMSO2 (algorithm version 1.1.1) data is the second public release of the sulfur-dioxide products derived from OMI observations. Changes from the previous version (V1.0.0) are listed below, in the Release History.

Known Issues List

This section describes significant issues related to the OMSO2 v1.1.1 product:

1. Negative SO_2 artifacts of about 1 DU are produced when upper level troughs (high total ozone) amplify and extend across the ozone profile climatology boundary between middle and high latitudes. The current OMTO3 algorithm generates false residuals due to use of the wrong ozone profile.

Col 3
V1.1.1

Col2

V0.9.6

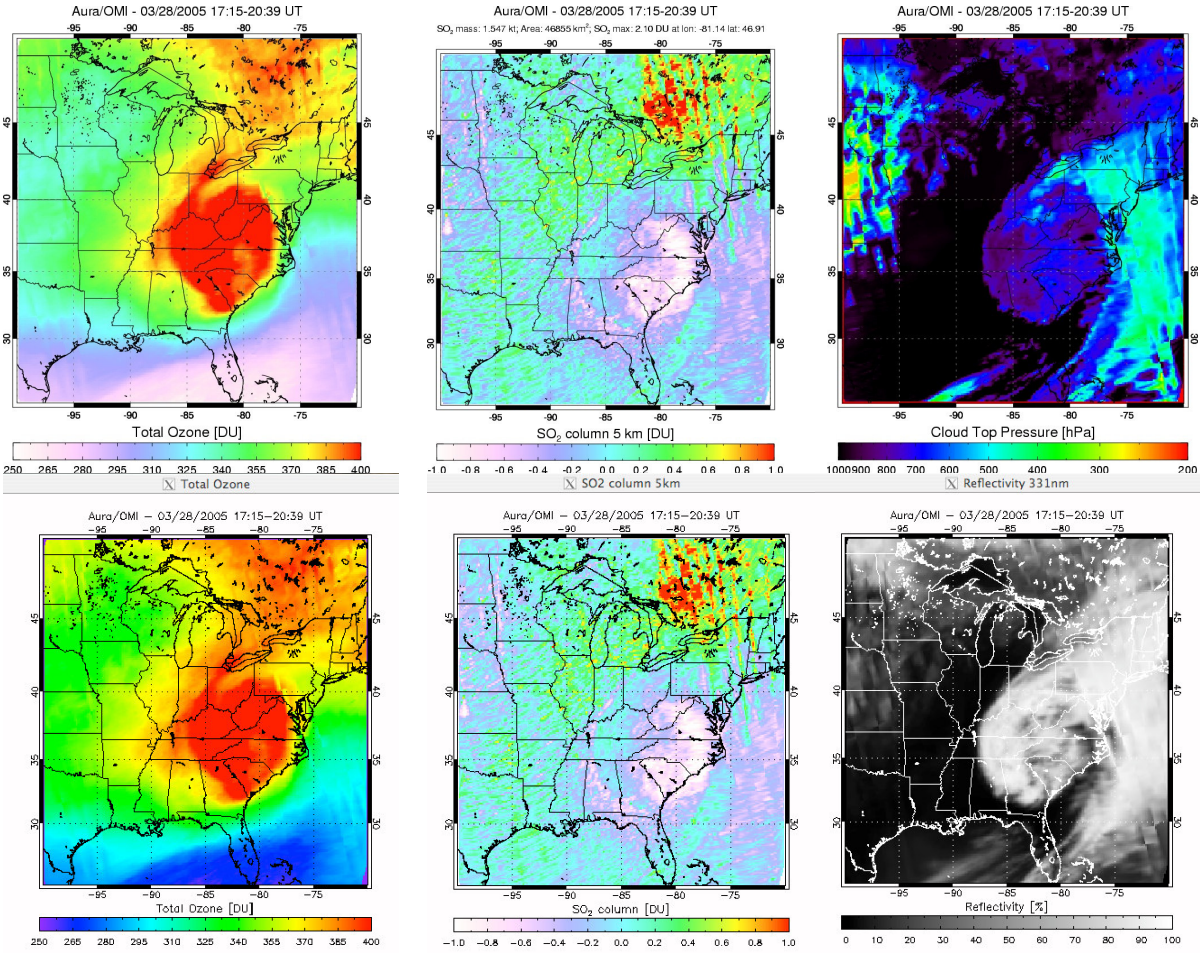

Figure 1. An example of negative SO_2 retrievals over southeast United States due to use of improper ozone profile climatology. It looks like the sliding residual correction might have been dragged down by the negative SO_2 region so that high positive SO_2 shows up north of that region

2. SO_2 artifacts (both significant positive and negative SO_2 values) are sometimes observed over cloudy regions, especially at the edges of clouds. They are possibly due to the incomplete corrections of Ring effects or wavelength shifts in the measured radiance or a combination of these two effects.
3. The retrieved SO_2 has displayed some broad patterns (region with negative values) that are usually associated with low radiances, such as the measurements at high ozone or high solar zenith angles, typical conditions at the high latitude regions. The measurements of low radiances are affected more by stray lights and the intrinsic instrument noises.
4. Incorrect (too low) terrain pressure or radiative cloud pressures (RCP) lead to erroneous fill values in the TRL data. Incorrect (low) RCP can also lead to fill values in TRM data fields due to the blocking of the signals from the a priori SO_2 profile that is completely under the high cloud.
5. The intrinsic noise in OMI radiance measurements leads to noise in SO_2 retrievals. This intrinsic SO_2 noise is at level higher than the typical signals from anthropogenic SO_2 pollutions. Consequently daily observations of anthropogenic SO_2 are limited to area with high concentrations (> 10ppb.). Note that the pixel quality flags in OMSO2 are reliable in identification of the true SO_2 signals for high loading (> 10 D.U.) cases, but are less reliable for low signal cases due to the intrinsic SO_2 noises.
6. Data collected over the South Atlantic and South America (from southern Peru southward) are affected by the South Atlantic Anomaly (SAA). Higher particle fluxes in this region result in random isolated spikes in SO_2.

Release History

V1.1.1 OMSO2 contains the following changes from the previous release V0.9.6:

1. OMSO2 produces 4 different estimates of the column density of SO_2 in Dobson Units ($1DU=2.69 \cdot 10^{16}$ molecules/cm^2) obtained under the different assumptions about the vertical distribution of the SO_2. Table 1 shows new and old SO_2 data names and description for each product.

2. V.1.1.1 OMSO2 uses new input data from collection V1.1.0 OMTO3 (for changes in the new OMTO3, please refers to its release specific information). One of the significant improvement in V1.1.0 OMTO3 is the switch from IR climatological cloud-top pressure to UV Radiative Cloud Pressure (RCP) inferred from Rotational-Raman Scattering (OMCLDRR). This switch has greatly reduced the Ring signature in the OMTO3 residuals, resulting in significant improvements in SO2 retrievals under cloudy conditions (Figure 1).

3. V.1.1.1 OMSO2 provides new ancillary information copied from pre-processing algorithms. See Table 2 for details.

4. Algorithm change: In V1.1.1 OMSO2 PBL data field no longer contains fill value for reflectivity greater than 30%. Although, we do not recommend using this product when

the radiative cloud fraction (RCF) exceeds 0.2, the PBL data are provided for error analysis purposes. The TRL data contain filled values when terrain pressure or RCP is less than ~500hPa. In such cases the cloud blocks most of the SO_2. As a result, the SO_2 weighting function approaches zero, no LF retrieval is done and the fill value is stored in the output. . The cloud-related fill values in TRM data occurs only when the OMI measured cloud top is higher than ~8-10 km. In general the number of cloud related filled values have reduced. In the STL (former 15 KM) product, the same criteria are applied, but no cloud is high enough to block the SO2. Retrievals are always attempted. One should see no fill values due to cloud blocking in the STL data field.

5. Algorithm change: in V1.1.1 OMSO2 sliding median uses only pixels with minimal cloud contamination (RCF < 0.15), while all pixels were used before (RCF < =1).

6. Algorithm change : Threshold for SO2 consistency flag is relaxed, it was 0.5 now it is 1.0. This means more pixels would be considered good SO2 pixels.

7. Algorithm change: Replace 0 with fill value (-999) for QAPercentCloudCover, QAPercentMissingData and QAPercentOutofBoundsData.

Table 1: SO_2 data field names with associated algorithm and quality flags

V. 0.9.6 names	V1.1.1 names	Description
SO2ColumnAmount_PBL	**ColumnAmountSO2_PBL** AlgorithmFlag_PBL QualityFlags_PBL	Planetary Boundary Layer (PBL) SO_2 column, corresponding to CMA of 0.9km, processed with BRD algorithm [Krotkov et al 2006, 2008].
N/A	**ColumnAmountSO2_TRL** AlgorithmFlag_TRL QualityFlags_TRL	Lower tropospheric SO_2 column, corresponding to CMA of 2.5 km, processed with Linear Fit (LF) algorithm [Yang et al 2007].
SO2ColumnAmount_05KM	**ColumnAmountSO2_TRM** AlgorithmFlag_TRL QualityFlags_TRL	Middle tropospheric SO_2 column, usually produced by volcanic degassing, corresponding to CMA of 7.5 km, processed with LF algorithm.
SO2ColumnAmount_15KM	**ColumnAmountSO2_STL** AlgorithmFlag_STL QualityFlags_STL	Upper tropospheric and Stratospheric SO_2 column, usually produced by explosive volcanic eruption, corresponding to CMA of 17 km. processed with LF algorithm.

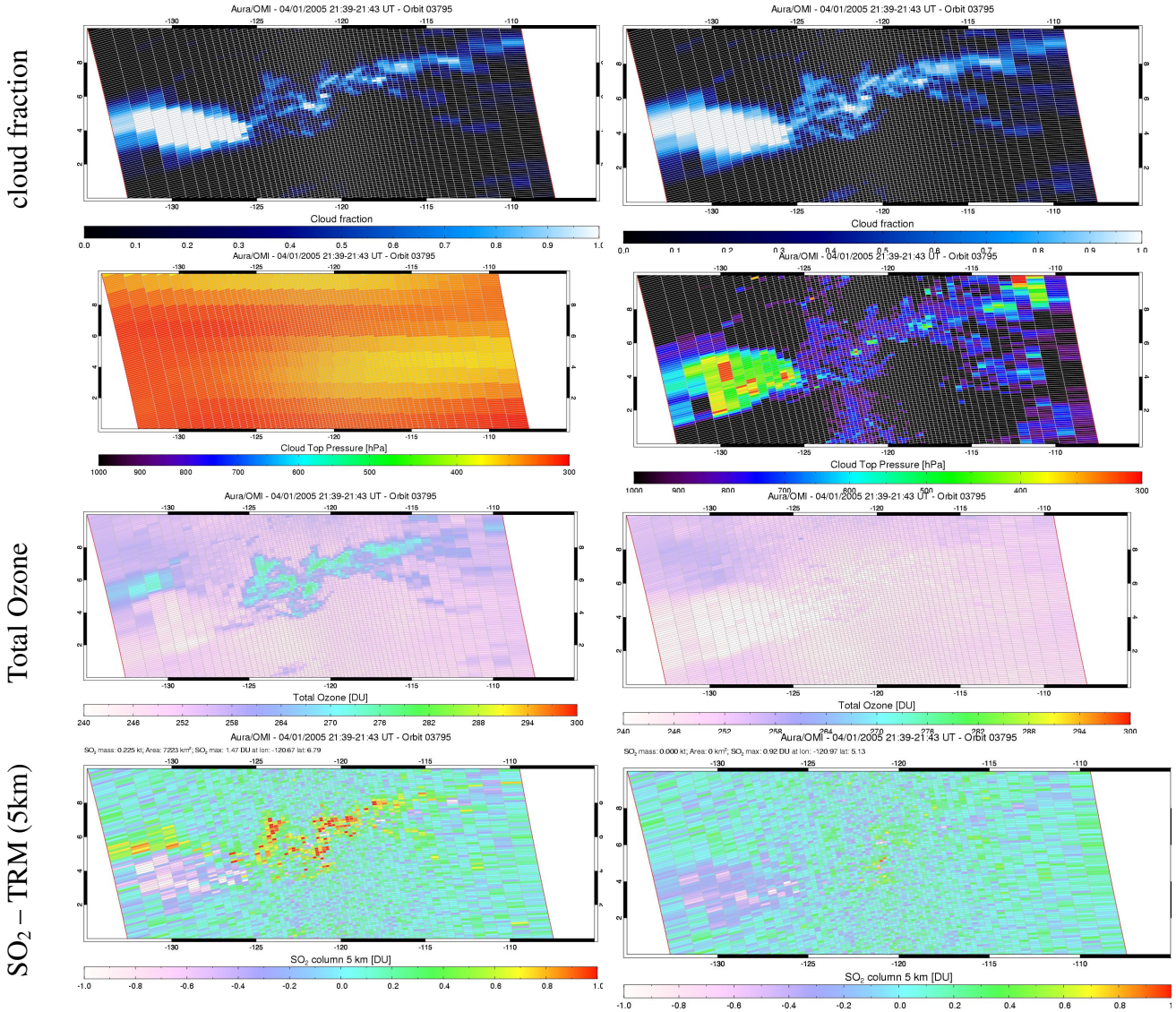

Figure 2 ITCZ region of dense and scattered clouds. Using IR cloud heights, total ozone (Row 2) shows positive artifacts up to 30 DU; SO_2 (Row 3) shows positive artifacts up to 2 DU. Using RR RCP, positive artifacts are used in both ozone and sulfur dioxide. Negative artifacts remain in both over dense clouds.

Table 2 Revised names for ancillary output data fields

V. 1.0.0 name	V1.1.1 name	Comment
N/A	LayerEfficiency factor (nLayers) OMTO3 V1.1.0	OMTO3 Ozone Layer Efficiency factor. Used to approximate SO2 weighting function.
CloudTopPressure OMTO3 V0.9.45	CloudPressure OMTO3 V1.1.0	Radiative Cloud Pressure (RCP) inferred from Rotational-Raman Scattering (OMCLDRR) to derive the total column ozone. Since the pressure corresponding to RCP is usually significantly below the cloud-top pressure climatology assumed in the V8 algorithm, the V8.5 derived column amounts have decreased over clouds. The magnitude of the decrease depends on cloud fraction, location, and solar zenith angle. Please refer to release specific information about OMTO3 for details
CloudFraction OMTO3 V0.9.45	RadiativeCloudFraction OMTO3 V1.1.0	The effective cloud fraction (fc) derived from the MLER model is used to estimate the Radiative Cloud Fraction (RCF). RCF characterizes the fraction of measured radiation that is scattered by clouds.

Prior version changes:

First public OMSO2 v0.9.6 contains several modifications from the provisional release (OMSO2 v0.9.29.1). The primary differences are in the new temperature dependent SO2 cross sections data [Bogumil et al 2000], new residual correction for background regions, different parameterization of the Air Mass Factors, and in high SO2 volcanic retrievals:

1. Instrument calibration errors are corrected by assuming median residuals are zero in background regions for each scan position (moving median method). This correction removes latitude dependent zero offsets in the retrievals.

2. When the atmospheric SO2 loading is low (<10 DU), the linear Band Residual Difference (BRD) algorithm (Krotkov et al., 2006) is suitable for SO2 retrieval.

3. For strong volcanic degassing and eruptions, SO2 loading can be very large and the BRD algorithm may fail. The new linear Fit (LF) algorithm has been developed to optimally select residuals from the set of available OMTO3 bands to retrieve SO2 under these conditions. The LF algorithm minimizes a subset of the residuals by simultaneously adjusting VC SO2, total column ozone, reflectivity at 331nm, and polynomial coefficients (linear and quadratic) to account for the wavelength dependent effect of surface albedo and aerosol on the effective reflectivity. In the OMSO2 product, 5 km and 15 km data processed with the LF algorithm are provided, in addition to BRD retrievals for the same vertical distributions.

The Maximum Likelihood spectral fit algorithm originally developed for operational SO_2 processing will be operationally employed when the OMI instrument calibration is better understood. This algorithm has maximum sensitivity for SO_2 in the PBL. For a description of this algorithm please refer to ATBD-OMI-04, *OMI Trace Gas Algorithms*, in Algorithm Theoretical Basis Document (ATBD), which also contains other algorithm related documents.

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