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*Supplement of*

# New-generation NASA Aura Ozone Monitoring Instrument (OMI) volcanic $SO_2$ dataset: algorithm description, initial results, and continuation with the Suomi-NPP Ozone Mapping and Profiler Suite (OMPS)

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**Supplemental Information**

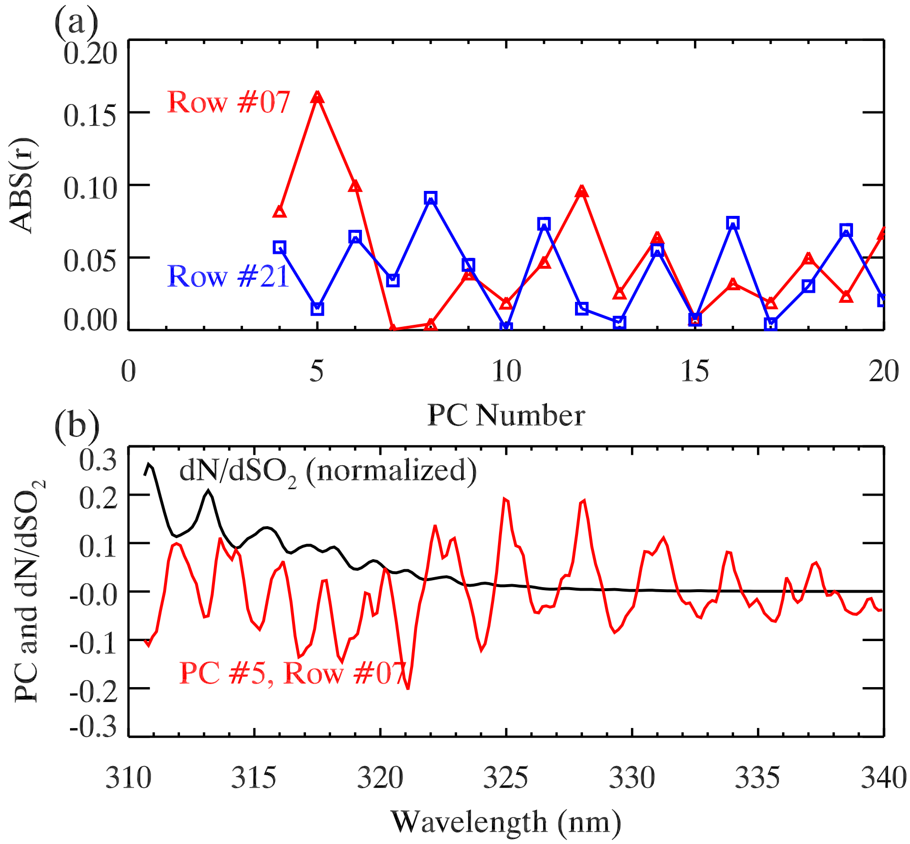


**Figure S1. (a)** The absolute value of correlation coefficients between a normalized $SO_2$ Jacobians spectrum and PCs (No. 4-20) derived from two OMIs rows, one with pixels inside the Kasatochi plume (Row #07, orbit 21635) and the other outside of the plume (Row #21). Only PC No. 5 from Row #07 is correlated with the Jacobians at the 95% confidence level. As a result, only the first 4 PCs were used in the first step fitting for initial $SO_2$ estimates for Row #07, whereas for Row #21, all 20 PCs could be used (with 6 being used in the actual first step fitting). **(b)** A comparison between the $SO_2$ Jacobians and PC No. 5 from Row #07 reveals $SO_2$ absorption signature in the PC, particularly for wavelengths < 318 nm.

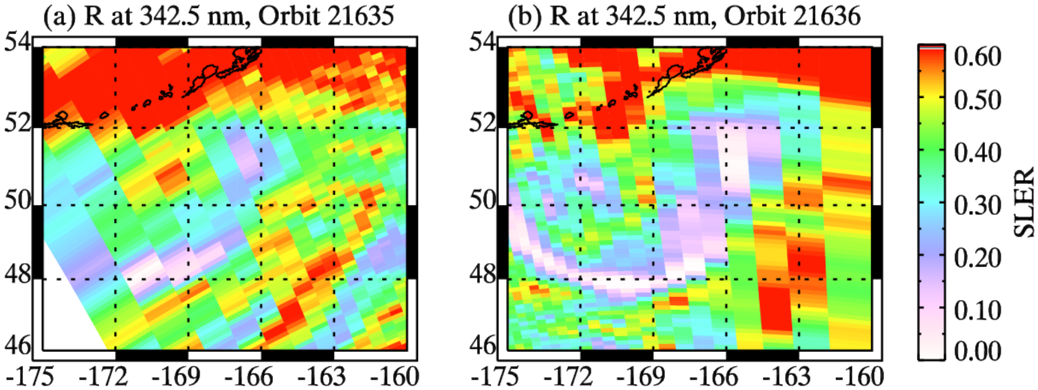


**Figure S2.** SLER at 342.5 nm derived from (a) OMI orbit 21635 on August 8, 2008 and (b) orbit 21636 on August 9, 2008, for the volcanic plume from the Kasatochi eruption.

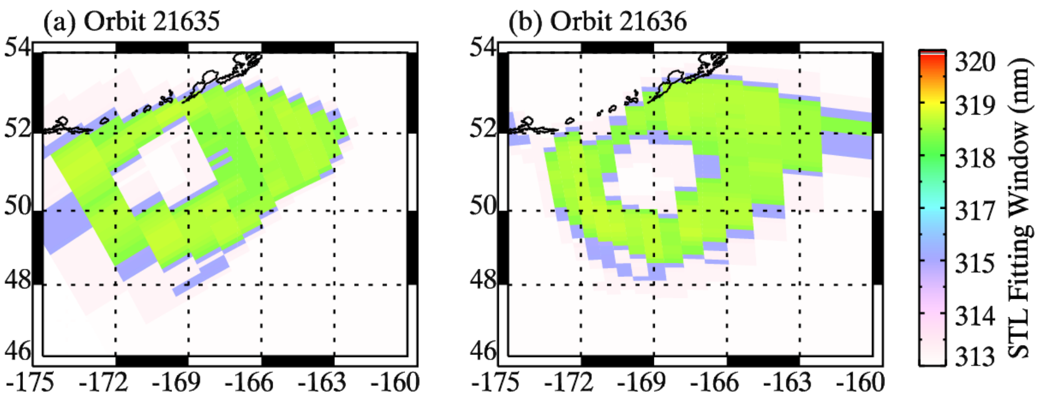


**Figure S3.** The left edge of the fitting window used in STL retrievals for (a) OMI orbit 21635 on August 8, 2008 and (b) orbit 21636 on August 9, 2008.

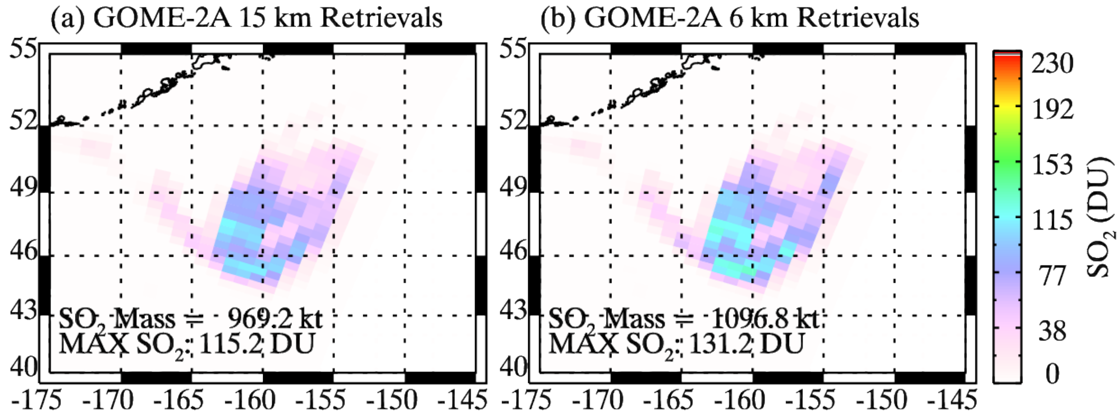


**Figure S4.** The GDP 4.7 (GOME Data Processor) operational GOME-2A $SO_2$ retrievals for the Kasatochi plume on August 9, 2008 assuming (a) a plume height of 15 km and (b) a plume height of 6 km. The estimated maximum $SO_2$ (115 DU for 15-km retrievals and 131 DU for 6-km retrievals) is much smaller than both OMI PCA (260 DU) and LF (246) STL retrievals for the same day. But this is expected given the larger pixel size of GOME-2 (80 × 40 $km^2$). The overall $SO_2$ loading from the GOME-2A 15-km retrievals is greater than OMI PCA STL (18-km) retrievals and smaller than PCA TRU (13-km) retrievals. The $SO_2$ mass estimated from GOME-2A 6-km retrievals, on the other hand, is only slight greater than that from 15-km retrievals. This weak dependence on assumed plume height is similar to the OMI LF retrievals and may be due to signal saturation at shorter wavelengths.

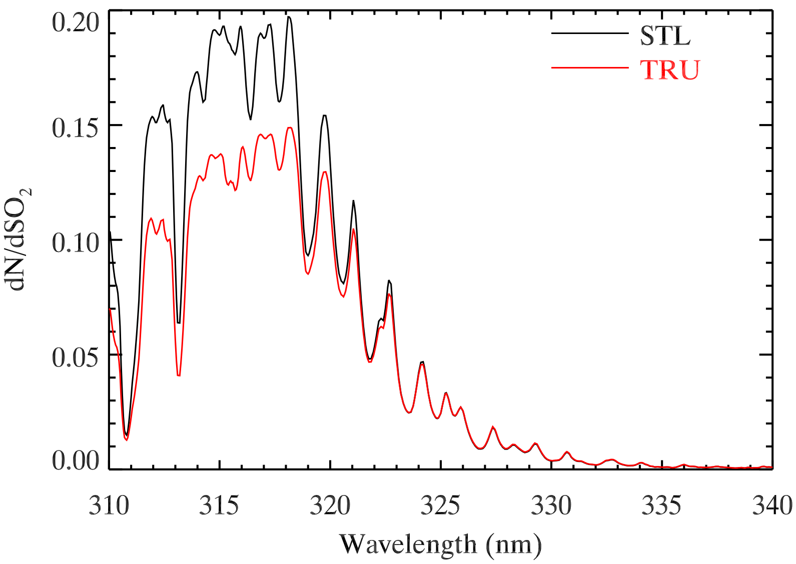


**Figure S5**. $SO_2$ Jacobians calculated with VLIDORT for typical conditions within the Kasatochi volcanic plume ($O_3$ = 325 DU, $SO_2$ = 250 DU, SZA = 35°, VZA = 50°, RAZ = 60°, constant SLER = 0.4) assuming STL (black line) and TRU (red line) $SO_2$ profiles.

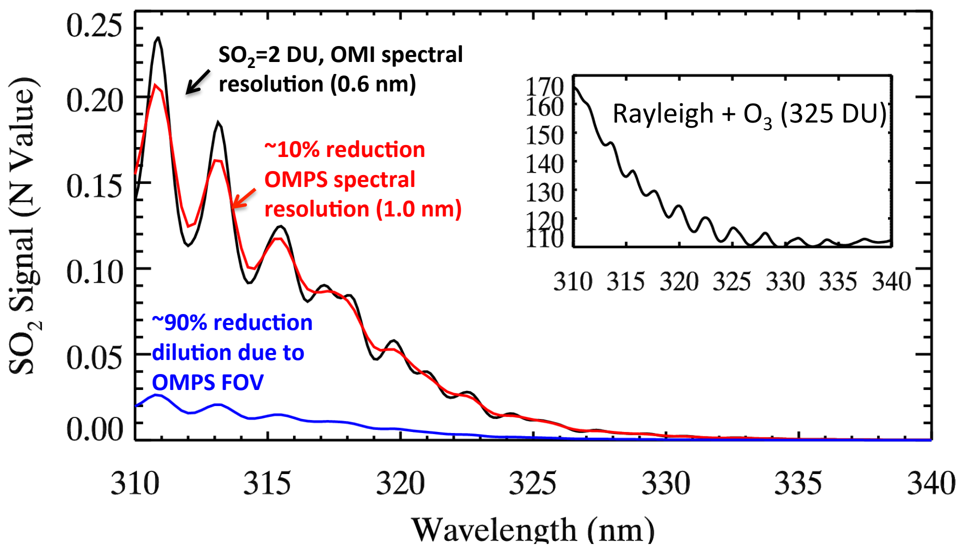


**Figure S6.** For relatively small $SO_2$ sources such as power plants and degassing volcanoes, typical $SO_2$ signal (in N value) for OMI (black line) is much smaller as compared with the signal for Rayleigh scattering and $O_3$ absorption (the insert). The calculation for the Rayleigh and $O_3$ only case assumes a mid-latitude $O_3$ profile with $O_3$ = 325 DU, surface pressure = 1012.35 hPa, SZA = 30°, VZA = 0°**,** RAZ = 90°, R = 0.05. The calculation for $SO_2$ assumes the same conditions, but includes 2 DU of $SO_2$ in the PBL. For this particular case, the coarser spectral resolution of OMPS leads to about ~10% reduction in $SO_2$ signal (red line, with $SO_2$ = 2 DU). If the $SO_2$ plume is isolated and has the size of an OMI pixel, the several times larger OMPS pixel may lead to even greater reduction in the expected $SO_2$ signal (blue line, assuming average $SO_2$ = 0.25 DU in the OMPS pixel).

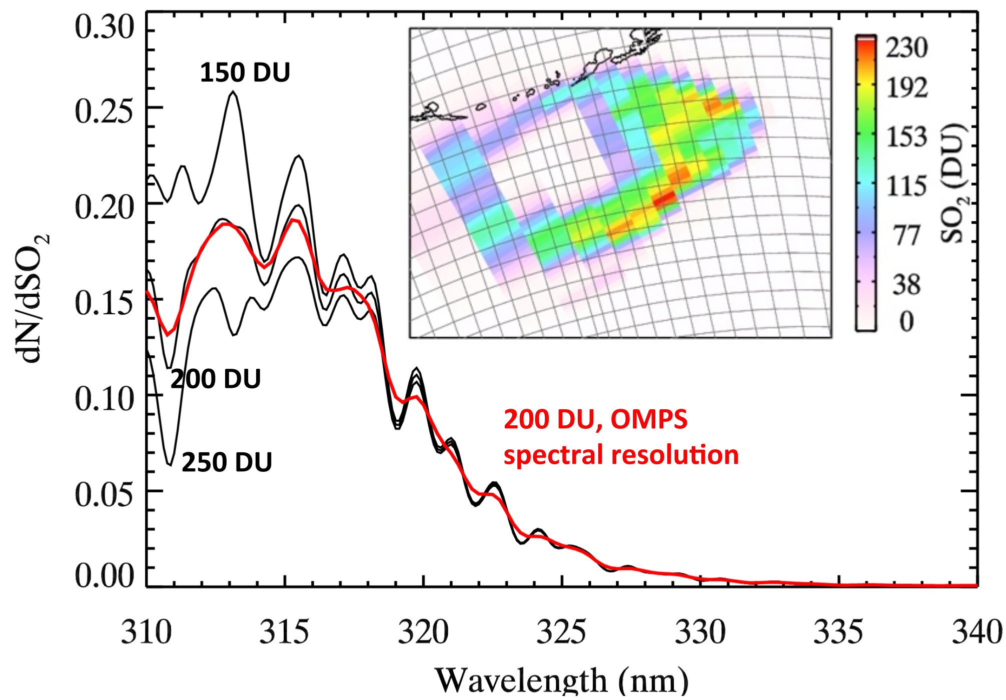


**Figure S7.** (Insert) Typical OMPS footprints overlaid on the OMI PCA STL retrievals of the Kasatochi plume on August 8, 2008 (orbit 21635), indicating substantial variability in OMI $SO_2$ within a single OMPS pixel, had the plume also been observed by OMPS. For a hypothetical case in which the average $SO_2$ loading in an OMPS pixel is 200 DU while OMI $SO_2$ ranges from 150 DU to 250 DU, the $SO_2$ Jacobians for OMPS (red line) and OMI (black lines) have very different shapes, particularly for wavelengths < 315 nm. As a result, the saturation issue will have different effects on OMI and OMPS retrievals and needs to be properly treated for both instruments.

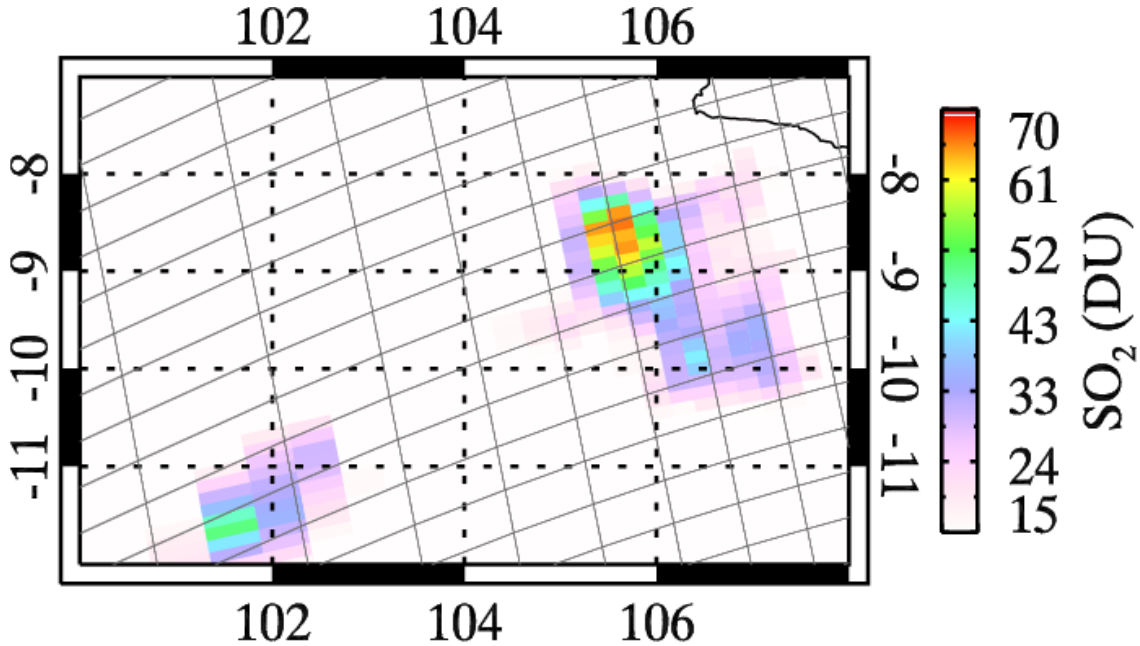


**Figure S8.** OMPS pixels (gray lines) overlaid on OMI retrieved volcanic $SO_2$ plume from the Kelut eruption on February 14, 2014. For the part of the plume with relatively large OMI $SO_2$ loading (near 8.5°N, 105.5°E), there are typically several OMI pixels within each OMPS pixel. OMI $SO_2$ amounts also change substantially within each OMPS pixel, from ~20 DU to nearly 70 DU. The maximum $SO_2$ retrieved from OMPS would therefore be smaller than OMI, even if the measurements had been made at the same time by the two instruments.