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New discoveries enabled by OMI SO2 measurements and future missions

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The Ozone Monitoring Instrument (OMI) on NASA Aura satellite makes global daily measurements of the total column of sulfur dioxide (SO2), a short-lived trace gas produced by fossil fuel combustion, smelting, and volcanoes. This talk highlights most recent science results enabled by using OMI SO2 data. OMI daily contiguous volcanic SO2 data continue 25+ climatic record by its predecessors (Total Ozone mapping Spectrometers 1978-2005), but higher SO2 sensitivity allows measuring volcanic plumes for a longer time as well as measuring passive volcanic degassing from space. New algorithm development allows direct estimating of SO2 plume heights to refine SO2 tonnages in largest volcanic plumes important for climate applications. Quantitatively, anthropogenic SO2 is more difficult to measure from space, since ozone absorption and Rayleigh scattering reduce sensitivity to pollutants in the lower troposphere. OMI data first enabled daily detection of SO2 burdens from individual smelters as well as observed SO2 pollution lofting from boundary layer and long-range transport in free troposphere. Interplay between volcanic and anthropogenic SO2 emissions resulted in highly variable SO2 pollution levels in Peru and Mexico City. We have updated our copper smelter analysis, which showed interesting new trends. Combining OMI data with trajectory models and aerosol/cloud measurements by A-train sensors (MODIS, CALIPSO) allowed tracking long-range transport of volcanic and anthropogenic aerosol/SO2 plumes. These studies placed new constraints on conversion rates of SO2 to sulfate at different heights from free troposphere to the lower stratosphere. We describe new techniques for spatial and time averaging that have been used to determine the global distribution of anthropogenic SO2 burdens, and the efficacy of abatement strategies. OMI seasonal to multi-year average images clearly show the world-highest consistent SO2 pollution in eastern China, mostly due to the burning of high-sulfur coal in its many coal-fired power plants. Recently, China's government has instituted nationwide measures to control SO2 emissions through the adoption of flue-gas desulfurization technology (FGD) on new power plants; and even greater measures were adopted in the Beijing area in anticipation of the Olympic Games. We demonstrate that the OMI can pick up both SO2 and NO2 emissions from large point sources in northern China, where large increases in both gases were observed from 2005 to 2007, over areas with newly established power plants. The OMI SO2/NO2 ratio generally agrees with the estimated emission factors for coal-fired power plants based on a bottom-up approach. Between 2007 and 2008, OMI detected little change in NO2 but dramatic decline in SO2 over the same areas. While the almost constant NO2 levels between the two years imply steady electricity generation from the power plants, the large reduction in SO2 confirms the effectiveness of the FGD units, which likely became operational between 2007 and 2008. Further development of satellite detection and monitoring of point pollution sources requires better than 10km ground resolution. We show how planned Dutch /ESA TROPOMI and NASA GEOCape missions will advance the art of measuring point source emissions in coming decade.