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A New Era of Satellite Remote Sensing of Atmospheric Composition

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Atmospheric composition including aerosols and gases has been observed extensively from Low Earth Orbit (LEO), providing one to two observations per day. Meteorological satellites have long provided aerosol optical properties from both LEO and Geostationary Earth Orbit (GEO). Since the launch of the Geostationary Environment Monitoring Spectrometer (GEMS) in 2020, we now can observe both aerosols and gases at unprecedented spatiotemporal resolution from GEO. Geostationary Ocean Color Imager 2 (GOCI-II) and Advanced Meteorological Imager (AMI) have also provided aerosol dataset from the same GK-2 platform. GEMS, the first ultraviolet-visible instrument for air quality observation from GEO has provided column amounts of atmospheric pollutants (O3, NO2, SO2, HCHO, CHOCHO, and aerosols) every hour to capture their diurnal variations. Details of the GEMS dataset are presented, including validations, calibration, and case studies of volcanic eruption, urban pollution, industrial activities. Calibration/validation activities are critical to diagnose and improve the overall data quality including the ASIA-AQ Field Campaign, Pandora Asia network (PAN), PEGASOS, GMAP/SIJAQ, ACCLIP, and international CAL/VAL team works. Faster sampling rates at higher spatial resolution increase the probability of finding cloud-free pixels, leading to more observations of aerosols and trace gases than have been possible from LEO. High-temporal-resolution observations captured diurnal variations in air pollution across a broader region, enabling new applications that leverage hourly datasets. With the launches of TEMPO over North America in 2023 and Sentinel-4 over Europe in 2025, the GEO-Ring, a geostationary satellite constellation for atmospheric composition monitoring, has become a reality, as recognized by the Committee on Earth Observation Satellites (CEOS).