Satellite remote sensing of trace gases: Improving the understanding of composition, chemistry and climate change

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Atmospheric trace gases (e.g., O_3, NO_2, SO_2, CO, HCHO, CH_4, CO_2, etc.) play a momentous role in the Earth's radiative balance, climate change, atmospheric chemistry, human health, crop yield, eco-system, biogeochemistry and geosphere-biosphere interactions. Due to variety of sources, sinks, and chemical transformations under the dynamic atmosphere, trace gases exhibit large heterogeneity on spatial and temporal scales. Previous generation of satellites provided a broad picture of distribution of various trace gases (NO_2, CO_2, etc.) at a coarse resolution with limited spatial coverage and accuracies. With advancement in technology and concern about the climate change and air quality, remote sensing of trace gases has improved in terms of accuracies, spatial resolution, temporal and spatial coverages. Quick visualisation of spatial distribution of many of trace gases (NO_2, SO_2, CO, HCHO, etc.) over the Indian region is made available in near-real time on web portal. Some of the trace gases (e.g., HCHO) which were difficult to measure are now estimated with fairly good accuracy. Higher accuracy in estimation of columnar CO_2 has allowed to study the variations of tiny magnitude, i.e., 0.25 to 1% y^{-1} in the growth rate and its linkage with sources/sinks. Though ground level O_3, an important air pollutant and crucial for chemistry of trace gases, is not possible to measure using satellite so far, satellite observations of NO_2 and HCHO are shown to be crucial for estimating ground-level O_3 with fairly good accuracy of ~5 ppbv with the help of machine learning. In recent time, excellent sensitivity of satellite sensor allowed to detect very weak signal of some of the trace gases from geostationary orbit (at ~36000 km) and made possible to study diurnal variations. Synergy of satellite observations, in situ measurements and model (conventional and machine learning) would deepen our understanding on composition, chemistry and climate change.