Using a Ground-based Spectrometer, Satellite Data, and Atmospheric Model to Evaluate Discrepancies in Southeast Asia Air Quality

Fernando Santos

National University of Singapore, Singapore

Author list (excluding presenting author)

Santo V. Salinas, Liya Yu, Li Tan, Abdus Salam, Surassawadee Phoompanich, Mohd Latif, Erna Adiningsih, Emma Knowland

Abstract

Global emissions from industrial and transport activities, combined with land changes for intensive agriculture, have steadily increased since the pre-industrial era, driven by economic and population growth. These activities significantly impact local and regional air quality in Southeast Asia (SEA). In Singapore, air pollution levels are strongly influenced by atmospheric circulation, which is governed by meteorological conditions and large-scale patterns such as monsoon dynamics and biomass burning events. The air quality in the region is also affected by emissions from large-scale industrial, aviation, and shipping activity, and the differing weather patterns of the northeast and southwest monsoons further complicate the transboundary transport of pollutants, leading to diverse impacts on local air quality. To understand these impacts, it is crucial to observe pollutants from satellites accurately. One such instrument is the Geostationary Environment Monitoring Spectrometer (GEMS), the first instrument in the geostationary constellation (GEMS, TEMPO, and Sentinel-4) and provides hourly data essential for air quality monitoring. However, satellite observations in SEA are challenging due to high cloud cover, heavy particle pollution, variations in the O_3 profile within the boundary layer, viewing geometry angles, biomass burning, and stratospheric intrusion events, all of which can reduce the sensitivity of near-surface retrievals. Continuous spatial and temporal observations from remote sensing satellites are necessary to address the complexity of identifying sources and transport pathways of emissions, which provide unique and valuable data. To better understand and reduce biases between ground-based and gridded trace gas datasets, we conducted an exploratory data analysis using NO_2, SO_2, O_3 and HCHO products from the Pandora spectrophotometer, GEMS and GEOS-CF model. This analysis focuses on (a) identifying diurnal spatiotemporal biases using remote sensing data and (b) characterizing meteorological patterns in SEA. The results are expected to significantly reduce measurement uncertainties, enhancing Singapore's readiness to respond to major pollution events.

Early Career Scientist

NO, I am not an early career scientist.

IGAC Activities

TOAR: Tropospheric Ozone Assessment Report

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MANGO: Monsoon Asia and Oceania Networking Group