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Integrating Low-Cost Sensors with Multiscale Models to Quantitatively Identify Ozone Sources and Transport Patterns over the Tibetan Plateau

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Ozone (O_3) is a pivotal trace gas influencing global public health, ecosystem stability, and radiative balance. However, the scarcity of long-term, high-resolution air quality observations across the Tibetan Plateau (TP) hinders the understanding of O_3 dynamics in this climatically and ecologically sensitive region. In this study, we integrated a high-density, low-cost sensor network (LCSN) along key inflow corridors in the TP with EAC4 reanalysis data for three-dimensional spatiotemporal analysis. Iterative discrete wavelet transform (IDWT) and Lagrangian transport diagnostic methods were innovatively used to quantify the dominant role of meteorologically driven regional transport and photochemical generation from local anthropogenic sources in driving surface O_3 extremes. Results show that the fusion of LCSN and reanalysis data provided a reliable, dynamic 3-D dataset at high temporal and spatial resolution for exploring regional O_3 production and transport. Key quantitative findings indicate that extreme surface O_3 pollution during summertime was driven by a coupled "stratosphere–monsoon" mechanism: stratospheric intrusion (SI) (contributing ~50.2% of the pollution signal) overlapped with monsoon-driven long-range transport of polluted air masses from upwind South Asia (~28.7%), while local photochemical generation played a lesser role (~21.1%). Dry conditions and enhanced solar radiation acted as critical amplifiers of O_3 pollution over the plateau. These findings provide the first observationally constrained, quantitative fine-scale source attribution of summertime surface O_3 extremes in the TP, demonstrating the critical role of LCSNs in supplementing traditional monitoring. The study provides a transferable framework for applying affordable LCSNs in high-altitude or resource-limited environments, supporting both the formulation of targeted mitigation strategies and collaborative international air-quality management.