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Why did $PM_{2.5}$ pollution persist in the Pearl River Delta, South China during the El Niño–La Niña transition in the 2015–2017 cold seasons despite emission reductions?

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$PM_{2.5}$ pollution in the Pearl River Delta (PRD) region, South China is notably influenced by cross-regional transport. Despite its importance, systematic studies focusing on the changes of transport contributions to $PM_{2.5}$ over multiple years and their driving factors are limited. During the cold seasons (Oct.-Jan.) of 2015-2017, both meteorological conditions and anthropogenic emissions in eastern China encountered rapid changes: Interannual climate variability, especially the transition from El Niño to La Niña, resulted in increasingly favorable conditions for $PM_{2.5}$ transport to the PRD; while simultaneously, pollution control measures notably reduced pollutant emissions in both the PRD and its upwind regions. These changes provide a unique opportunity to explore the variations of transport contribution to $PM_{2.5}$ in the PRD and their driving factors.

For this purpose, factor separation method was applied based on WRF-CMAQ simulations for the three years. Transport contributions, defined as the contributions from emissions outside the PRD, are split into direct transport (in the form of $PM_{2.5}$), indirect transport (in the form of the precursors of secondary $PM_{2.5}$ components), and background (sources outside the modeling domain) contributions.

Results show that during three polluted seasons from 2015 to 2017, the overall transport contributions accounted for 70%, 74% and 78%, respectively, of the $PM_{2.5}$ levels in the PRD. Direct transport is not only the main contributor to $PM_{2.5}$ (~50%), but also the driver of yearly increases in transport contribution. Based on sensitivity simulations, the influence of meteorological and emission changes on various sources of $PM_{2.5}$ were further quantified to reveal the detailed reason behind their increasing transport contributions.

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