

## Twenty Years of Observed Tropospheric Ozone Increases Across the Northern Hemisphere

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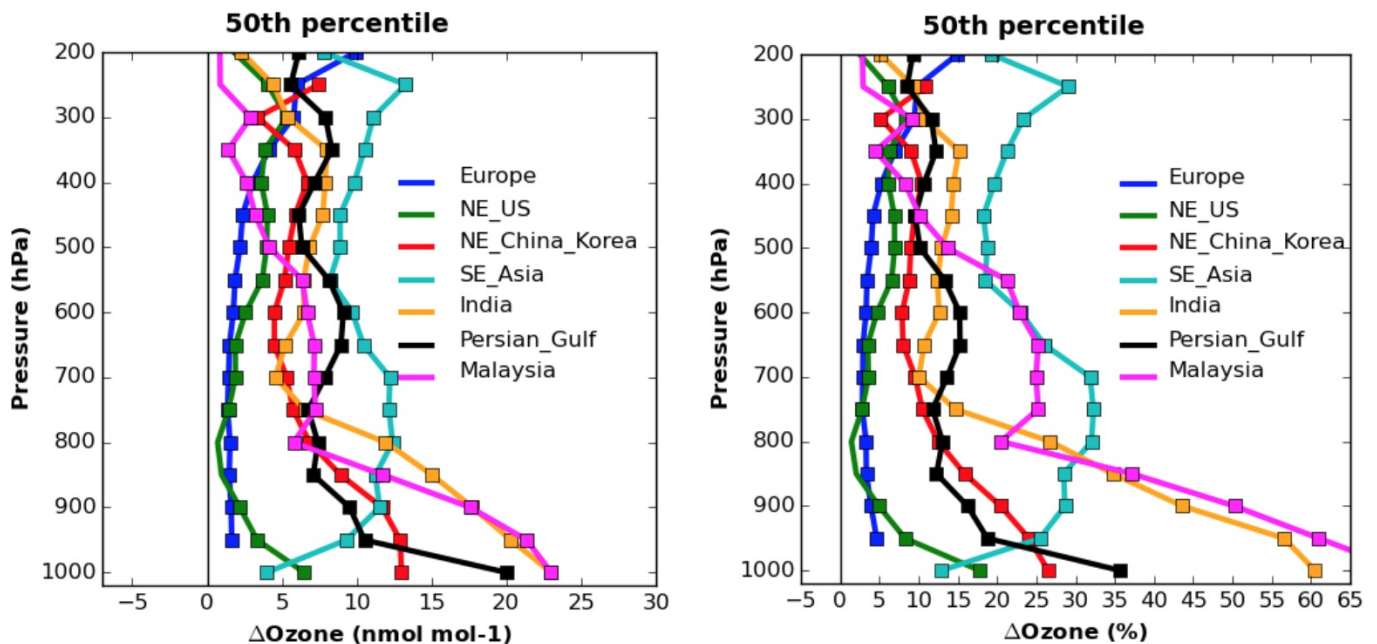
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Tropospheric ozone is the third most important greenhouse gas, is detrimental to human health and crop and ecosystem productivity, and controls the oxidizing capacity of the troposphere. Due to tropospheric ozone's high spatial and temporal variability, the current *in situ* monitoring network has been insufficient for quantifying ozone's net global change on time scales less than two decades. The In-service Aircraft for a Global Observing System (IAGOS) has used commercial aircraft to monitor ozone worldwide since 1994. Here we show IAGOS observations that demonstrate 20 years of ozone increases above seven polluted regions distributed across the northern tropics and midlatitudes. Annual median ozone increased in nearly all levels of the troposphere, above all regions, including the eastern U.S. and western Europe, where ozone precursor emissions have decreased. Ozone reductions were limited to extreme ozone pollution events in the lower troposphere of the eastern U.S. and western Europe.



**Figure 1.** Annual differences in the 50<sup>th</sup> percentile of ozone (nmol mol<sup>-1</sup>). The differences are calculated at each vertical pressure level between 1994–2004 and 2011–2016 above Europe (blue), Northeast U.S. (green), Northeast China / Korea (red), Southeast Asia (cyan), India (orange), and between 1998–2005 and 2011–2016 above Persian Gulf (black). The statistically significant differences between both periods at each pressure level are indicated with a square.