Responses of surface ozone air quality to anthropogenic nitrogen deposition

Yuanhong Zhao¹, Lin Zhang¹, Amos P. K. Tai², Youfan Chen¹, Yuepeng Pan³
1. Peking University  2. The Chinese University of Hong Kong  3. Chinese Academy of Sciences

Key massages:
The impacts of anthropogenic nitrogen deposition on surface ozone are important at regional scales. The complexity of biosphere-atmosphere interactions can have important implications for future air quality prediction.

Increasing inputs of reactive nitrogen from the atmosphere can lead to complex environmental and climate consequences. 

We focus on how human-induced nitrogen deposition may affect surface ozone air quality through land-atmosphere interactions.
Surface ozone air quality response to enhanced nitrogen deposition through land-atmosphere exchanges

We build this asynchronously coupled system of GEOS-Chem and CLM to investigate the influences of nitrogen deposition on surface ozone from the individual processes and the overall effects.
GEOS-Chem simulated atmospheric nitrogen deposition

Total nitrogen deposition

Anthropogenic contribution

Total nitrogen deposition: land: 65 Tg N a⁻¹

Anthropogenic contribution: land: 46 Tg N a⁻¹

NH₄⁺ wet deposition: r=0.86 bias=-5%

NO₃⁻ wet deposition: r=0.70 bias=-8%

NH₄⁺ wet deposition: r=0.81 b=4%

NO₃⁻ wet deposition: r=0.53 b=-23%

Anthropogenic contribution: r = 0.60 b = 0.3%
Impact of anthropogenic nitrogen deposition on land properties

Subsequent responses of LAI changes

Isoprene emissions are more sensitive to LAI changes at lower LAI area.

The dry deposition velocity tends to increase with increasing LAI.

Biogenic emissions and ozone dry deposition show different sensitivity to LAI changes.
Responses of surface ozone pollution in June-July-August

(a) Nitrogen deposition

(b) Climate change

(c) Land use change

(d) Dry deposition

(e) Biogenic VOCs emissions

(f) Soil NOx emissions

Surface ozone changes due to increased dry deposition loss and biogenic VOC emissions are largely offset.

Enhanced soil NOx emissions increases the surface ozone concentration over the globe except for NOx saturated areas.

- The influences of anthropogenic nitrogen deposition may largely offset the surface ozone reduction due to historical land use change.
- Large uncertainties exist in this interaction since the estimated surface ozone responses rely heavily on the parameterizations of surface-atmosphere exchange processes.
Back-up slides
Modifications implemented to the CLMv4.5 model

1. Implement a process-based parameterization of soil NO\textsubscript{x} emissions based on NO\textsubscript{x} and N\textsubscript{2}O emission ratios as described by Parton et al. (2001).

2. Add a process-based NH\textsubscript{3} volatilization parameterization in CLM following Xu and Prentice (2008) to avoid extremely high soil nitrogen content over desert areas.

3. Consider factors (soil inorganic nitrogen concentration, the fine root mass, and soil temperature) that limit plant nitrogen uptake capacity.

Soil NO\textsubscript{x} emissions from GEOS-Chem, original CLM and modified CLM
Compare LAI simulated by original CLM model and modified model with MODIS and AVHRR observations.

MODIS LAI

AVHRR LAI

CLM org

CLM mod

AVHRR: $r=0.63$ bias=28%
MODIS: $r=0.72$ bias=51%

AVHRR: $r=0.64$ bias=11%
MODIS: $r=0.73$ bias=40%
The CLM LAI overestimation leads to the largest uncertainty over Southeast China.

**CLM LAI**

- **Oxiprene emissions**: 5.6 Tg a\(^{-1}\)
- **MODIS LAI**: 8.2 Tg a\(^{-1}\)

**Ozone dry deposition**

**Ozone concentration (JJA)**

[Color scales for each diagram are shown, indicating concentration levels in Tg a\(^{-1}\), 10\(^{11}\) atoms C m\(^{-2}\) s\(^{-1}\), and ppb, respectively.]