# Impact of Land Cover and Land Use Change on Surface Ozone

## 1. Abstract

Ozone air quality is a critical global environmental issue. Although it is clear that industrialization and urbanization has increased surface ozone through enhanced emissions of its precursors, much less is known about the role of changes in land cover and land use. Human activities have substantially altered the global land cover and land use through agriculture, urbanization, deforestation, and afforestation. Changes in land cover and land use affect the ozone levels by altering soil emissions of nitrogen oxides (NOx), biogenic emissions of volatile organic compounds (VOCs), and dry deposition of ozone itself. This study performed a series of experiments with a chemical transport model based on satellite observation of land types to analyze the influences of changes in land cover/land use and their impact on surface ozone concentration. Our results indicate that land cover change explains 1-2 ppbv of summertime surface ozone increase in the Western United States and 1-6 ppbv of increase in Southern China between 2001 and 2012. This is largely driven by enhanced isoprene emissions and soil NOx emissions. It is also found that land cover change itself elevates summertime surface ozone in Canadian coniferous forests by up to 4 ppbv mainly through substantial decreases in ozone dry deposition associated with increases in vegetation density in a warmer climate.

## 2. Approach

- **Land Cover and Land Use Change**
- **Isoprene**
- **Soil NOx**
- **Dry Deposition**

### Surface Ozone Change

![Figure 1. Outline for this study.](Image)

## 3. Isoprene Emission Changes

(a) Percentage difference between 2001 and 2012

<table>
<thead>
<tr>
<th></th>
<th>Crops → Grasslands</th>
<th>Mixed Forests → Woody Savannas</th>
<th>Barren → Grasslands</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Biogenic isoprene fluxes (2001)</td>
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<td>(b)</td>
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### Figure 2. Isoprene emission changes between 2001 and 2012. 2(a) shows the changes by percentage, in which the causative land cover changes are marked in textboxes. For reference, isoprene fluxes based on land cover in 2001 are shown in 2(b).

### Are simulated biogenic isoprene emission changes real or not?

Isoprene has a lifetime of less than an hour against oxidation and produces HCHO with a high yield. Satellite observation of HCHO columns changes are used to verify isoprene emission changes. Figure 3(a) rules out the impact of temperature but still includes factors other than land cover change, such as oil/gas exploitation.

### Figure 3. (a) shows the change in temperature-controlled HCHO from 2005 to 2014. (b) shows modeled HCHO change caused by land cover change between 2001 and 2012.

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**Between 2001 and 2012:**
- Land cover change accounts for up to 2 ppbv of summertime ozone increase in Western United States.
- Afforestation campaign in China increases isoprene emissions, thus increases surface ozone by 1-6 ppbv.

## 4. Soil NOx Emission Changes

(b) Soil NOx emission fluxes (2001)

![Figure 4. Soil NOx emission changes between 2001 and 2012. 2(a) shows the changes by percentage, in which the causative land cover changes are marked in textboxes. For reference, soil NOx emissions fluxes based on land cover in 2001 are shown in 2(b). Soil NOx emission changes in sparsely vegetated regions are significant in percentage. Changes in the Western United States and Southern China are also significant.](Image)

## 5. Ozone Dry Deposition Changes

- **Expansion of Evergreen Needleleaf Forests**
- **Grasslands → Croplands**

![Figure 5. Ozone dry deposition changes caused by land cover change between 2001 and 2012.](Image)

## 6. Conclusion

### Figure 6. Changes of ozone monthly mean in July between 2001 and 2012 caused by land cover change.

<table>
<thead>
<tr>
<th></th>
<th>A. Middle Southern China</th>
<th>B. Western USA</th>
<th>C. Texas</th>
<th>D. Canadian Coniferous forests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-6 ppbv increase</td>
<td>1-2 ppbv increase</td>
<td>2-3 ppbv decrease</td>
<td>1-4 ppbv increase</td>
</tr>
</tbody>
</table>

### Acronyms:
- **MODIS**: Moderate-resolution Imaging Spectroradiometer
  - The Model of Emissions of Gases and Aerosols from Nature

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