Influence of Air Pollutant Emission Controls on the “Climate Penalty” in the United States

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“Climate penalty”

- “Climate penalty” is the increases in concentrations of air pollutants that pose human health risks, resulting from regional climate warming, in the absence of precursor emission changes
- Ozone (O₃), and PM₂.₅
- Meteorological variables: T, (U,V), precip
- “Climate penalty” – a function of both climate and emissions
- Research objective – quantify the influence of changes in emissions on the “climate penalty”
IGSM-CAM-GEOS-Chem modeling framework

- **3 climate policy scenarios**
  - No climate policy: 2100 radiative forcing = 9.7 W/m²
  - Policy 4.5: 2100 radiative forcing = 4.5 W/m²
  - Policy 3.7: 2100 radiative forcing = 3.7 W/m²

- **4 climate sensitivity**: 2.0°C, 3.0°C, 4.5°C or 6.0°C

- **5 different initial conditions** one initial condition

- **30-year simulations around 2000, 2050, and 2100**
  - 1981→2010
  - 2036→2065
  - 2085→2115

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<table>
<thead>
<tr>
<th>Meteorological years</th>
<th>Name of the scenarios</th>
<th>Emissions</th>
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</thead>
<tbody>
<tr>
<td>REF</td>
<td>REF-50</td>
<td>50% of 2006 US non-GHG emissions</td>
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<tr>
<td>2006 emissions</td>
<td></td>
<td></td>
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<tr>
<td>Current climate:</td>
<td>REF+50</td>
<td>150% of 2006 US non-GHG emissions</td>
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<td>1991-2010</td>
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<tr>
<td>Future climate:</td>
<td>REF+100</td>
<td>200% of 2006 US non-GHG emissions</td>
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<td>2091-2110</td>
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Adapted from Mingwei Li et al., in prep
PM$_{2.5}$ climate penalty is enhanced with emissions in Northeastern US
O₃ climate penalty is enhanced with increases in emissions
Addition policy benefit obtained from emissions mitigation

In addition to direct benefit of emissions mitigation, 1.46 ppb.

There is an indirect benefit of avoided climate penalty, 0.28 ppb, 20% of the direct benefit.

Under current climate:

\[ \text{O}_3 \text{ concentration of REF: } 48.00 \text{ ppb} \quad \text{minus} \quad \text{O}_3 \text{ concentration of REF-50: } 46.54 \text{ ppb} = 1.46 \text{ ppb} \]

\[ \text{O}_3 \text{ climate penalty of REF: } 4.68 \text{ ppb} \quad \text{minus} \quad \text{O}_3 \text{ climate penalty of REF-50: } 4.40 \text{ ppb} = 0.28 \text{ ppb} \]

20%
Takeaways

• PM$_{2.5}$ climate penalty is enhanced with increases in emissions in Northeastern US due to enhanced sulfate formation

• O$_3$ climate penalty is enhanced with increases in emissions

• Additional benefit of emissions mitigation policies from avoided climate penalty—20% of direct benefit from decreases in pollutant (O$_3$) concentration