• Air quality is sensitive to climate change, although the influences for PM2.5 are less clear as for ozone.

• Actions to mitigate greenhouse gas (GHG) emissions will not only slow climate change, but will also bring co-benefits for improved air quality, through two mechanisms: reductions in co-emitted air pollutants, and slowing climate change and its effect on air quality (Fig 1).

Previous studies have focused on the local and regional co-benefits of GHG reductions, but tend not to analyze global effects in projected future scenarios.

West et al. (2013) studied the co-benefits of global GHG mitigation on surface air quality and human health both locally and regionally using a global CCM. They found that global GHG mitigation avoids 1.2-3.2 million premature deaths in 2100 from both O3 and PM2.5, and that the reduced co-emitted air pollutants are much more important than climate change for air quality. However, the estimated co-benefits are limited due to the coarse resolution (2x2.5).

Objectives

• Quantify the total co-benefits for air quality (O3 and PM2.5) in the U.S. in 2050 from global GHG mitigation, at fine resolution.

• Separate the co-benefits on U.S. air quality into contributions from the two mechanisms: co-emitted Air pollutants and changes in regional climate.

• Separate the co-benefits of domestic GHG mitigation from those from foreign countries’ GHG reductions.

• Study the air quality co-benefits of GHG reductions from different U.S. sectors.

• Analyze the co-benefits on human health (premature mortality in 2050) through those changes above.

Approach

We develop a comprehensive model framework to study the regional co-benefits via the two mechanisms:

1. Experimental design: We use a suite of models to conduct high-resolution (0.5° × 0.5°) global simulations with an emission reference scenario (REF) as a baseline scenario, following West et al. (2013). These two scenarios differ only in the application of a climate policy.

2. Results: For the simulation with global climate change mitigation policies (both 1 and 2), we find that:

   a) Overall the reduction in co-emitted air pollutants has a greater effect than slowing climate change, accounting for 80-90% of the total O3 decrease and 60-70% of the total PM2.5 decrease, consistent with global results (West et al. (2013)). For the emission benefit on PM2.5, it is more significant in urban areas where the anthropogenic emissions are greatly reduced in U.S. (not shown), while for O3 the emission benefit is uniform over the U.S., emphasizing the influence of background ozone changes.

   b) The benefits of slowing climate change vary from space and time. For PM2.5, it shows strong positive and negative influences in the U.S., especially in the Southeast. Examining the components of PM2.5, we find that these influences are dominated by trace metal species and unspeciated fine PM, which are likely related to the meteorological changes over the Gulf of Mexico, and the modeled sea salt and windblown dust emissions.

   c) Air quality co-benefits on the U.S. are significant for both PM2.5 and O3, and the domestic domain experiences decreases of 0.67 µg/m3 and 3.11 ppbv, though PM2.5 increases near the NM-TX border.

   d) The total co-benefits for PM2.5 are more striking in the east, especially in the southeast, while the benefits for O3 are consistent over U.S. PM2.5 benefits are influenced mainly by domestic air pollutant emission reductions, while O3 is strongly affected by global methane reductions and intercontinental transport.

Conclusions

1) The total co-benefits on O3 are fairly uniform throughout CONUS, but the PM2.5 co-benefits are higher in the east (1-3µg/m3), with strong positive and negative influences in the Southeast.

2) Reductions of co-emitted air pollutants have a greater influence on both PM2.5 (60% of total) and O3 (80% of total) than the second co-benefits mechanism via slowing climate change, consistent with West et al. (2013).

3) Foreign countries’ GHG mitigation has a larger influence on the U.S. O3 decreases (accounting for 77% of the total decrease), compared with 23% from domestic GHG mitigation, highlighting the importance of global methane reductions and the intercontinental transport of air pollutants. For PM2.5, the benefits of domestic GHG control are greater (52% of total).

Uncertainties

• We didn’t account for the feedbacks of changes from land use and vegetation cover on climate and air quality in the future simulations.

• Direct effects of climate change are not included in the assessment, which can influence the downstream simulations of emissions. Emissions of black carbon and organic carbon are used to estimate the total primary PM emissions (both fine and coarse) making use of PM specialty profiles from the EPA, definitions of emission sectors, and Xing (2008) (Table 2).

• Future work

   a) Sensitivity analysis to see the benefits of emissions reductions from different U.S. sectors.

   b) Using BANMAP to analyze the health co-benefits due to those changes in concentration.

References


