Internal variability in projections of climate change impacts on air quality and health

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We use an ensemble simulation of economic activity, climate, and atmospheric chemistry to characterize internal variability in model-based projections of climate change impacts on air quality and human health. The ensemble is generated with a coupled modeling framework that includes an integrated global system model, a climate-chemistry model, and an air pollution health and economic impacts model. To weigh internal variability in the projections, we characterize climate-induced impacts on air quality at midcentury and the end of the century using multiple initial condition ensemble members and multidecadal simulations. The ensemble shows that internal climate fluctuations can significantly influence projections of climate change impacts on ozone and fine particulate matter pollution. Internal variability can lead to year-to-year disparities in the projected magnitude or direction of climate-induced effects on pollutant concentrations and misrepresentations of the impact of greenhouse gas mitigation policies. Compared to other major sources of uncertainty, we find that internal variability can be larger than the influence of emissions scenario or model response, but the noise it introduces can be filtered out with extended modeling (through initial condition ensembles or decadal simulations) or by increasing the spatial-scale of impacts. However, our results also indicate that with internal variability it may be difficult to detect an anthropogenic-forced signal in climate change air quality impacts over some regions, at midcentury, or under greenhouse gas mitigation scenarios. Additionally, we examine how internal climate variability propagates to projections of air-pollution-related mortality and morbidity, as well as monetized climate policy benefits. In our simulations, internal variability leads to a wide spread in projected health effects associated with climate change air quality impacts and the value of climate policy co-benefits. If not addressed, it can obscure future health risks or mask true policy impacts. We also show that in policy assessments internal variability can be a larger source of uncertainty than that due to health response and economic valuation.