Development of Risk-based Air Quality Management Strategies under Impacts of Climate Change

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Introduction

➢Climate change has been forecast to influence air quality on regional- and global-scales through perturbations in precursor emissions as well as atmospheric physical and chemical processes (Jacob and Winner, 2009).

➢ American Lung Association (2009) has reported that more than 60% of the populations (~186.1 millions in year 2009) in the United States live in counties where they are exposed to unhealthful levels of air pollution in the form of either ozone or short-term or year-round levels of particles.

➢Air Quality studies show that projected higher temperatures, faster photochemical rates and more stagnant meteorological conditions could increase ground-level ozone concentrations in the future.

➢To protect future air quality and human health, there is an increasing recognition of the necessity of incorporating the impacts of climate change into regional air quality planning process.

➢The goal of this poster is to provide a robust framework for decision makers developing effective climate-responsive air quality management strategies in an efficient manner.

Procedures for Developing Air Quality Management Strategies under Impacts of Climate Change

➢For air resources management, the impacts of climate change can be viewed as risks to air quality and air pollution-related human health, and the development of air quality management strategies in response to climate change should be considered in two stages: risk assessments and risk management **(Figure 1**).

➢The climate risk assessments for air quality management include identification and quantification of the climate change impacts and associated uncertainties. Risk management for mitigating the impacts of climate change on air quality includes determination of air quality targets, selections of potential air quality management options and identification of optimal air quality management strategies through risk-based decision-making models.

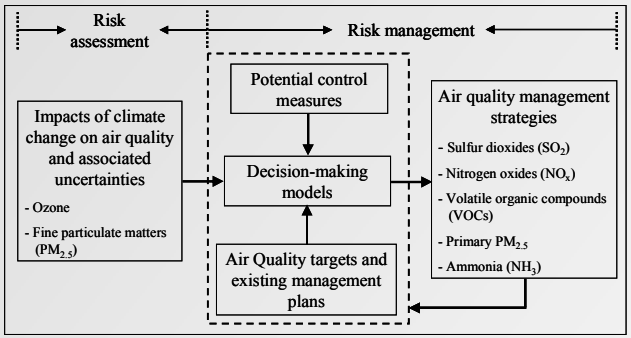


Figure 1. Framework for developing air quality management strategies under the impacts of climate change

Step 1. Identification and quantification of the impacts of climate change and associated

➢ The effects of climate change on air quality are estimated using global- or regional-scale atmospheric chemical transport models (CTMs) which are driven by general circulation model (GCM) simulations of future climate change (**Figure 2**).

➢ Comparisons between two scenarios are needed:

1) Base-case scenario: present air pollutant emissions and climate

2) Future scenario: present air pollutant emissions and **future climate**

➢The uncertainty in climate change forecasts is an important consideration in assessing the impacts of climate change on air quality and should be taken in account in the decision-making processes.

Figure 2. General GCM–CTM architecture for investigating the effect of climate change on air quality (Jacob & Winner, JGR, 2009)

Step 2. Determination of air quality targets under the impacts of climate change

➢ Determination of air quality targets should take into account the flexibilities of policy-making, feasibilities of air pollution control measures and uncertainties in decision-making due to incomplete information and knowledge.

➢ two types of air quality targets:

1) targets that offset the adverse effects of climate change on air quality.

2) targets that achieve prescribed air quality standards in the future.

Step 3. Selections of potential air quality management options

➢ Four types of air quality management options are available under the impacts of climate change:

1) Reduction-by-regulations: A traditional approach which decreases emissions through the imposition of emission standards or limitations.

2) Cap-and-trade program: A market-based approach which is flexible to achieve air quality targets at the least cost to society.

3) Wildfire management: Wildfire management is expected to improve air quality by reducing air pollutant emissions from unplanned fires, and it could be one of the options for air quality management under the impacts of climate change.

4) Individual actions: Power plants and motor vehicles are major sources of many air pollution precursors. Individual actions, induced by restrictions and economic disincentives, could improve air quality via energy saving, carpool and public transportation and others.

Step 4. Identification of optimal air quality management strategies through risk-based decision-making models

➢ It is important to identify optimal climate-responsive strategies among a wide variety of air quality management alternatives.

➢The optimal management strategies may represent combinations of various control measures which minimize costs of emission reductions or minimize the impacts of climate change on air quality when limited resources are considered.

➢Several approaches can be used to identify the optimal air quality management strategies through decision-making processes. Two major types of decision-making models are:

Model 1: Least-cost model

Minimize [*Total Air Quality Management Cost*]

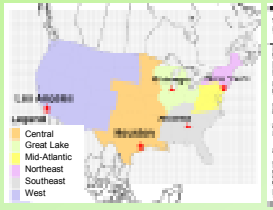
Subject to:

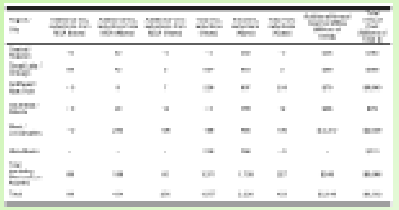
Decreases in ozone levels ≤ Differences between target and non-control
Decreases in $PM_{2.5}$ levels ≤ Differences between target and non-controls
Lower bounds ≤ Air pollution control measures ≤ Upper bounds

Model 2: Resource Allocation Model

Minimize [*Air Quality Effects of Climate Change*]

Example (the air quality target is to offset impacts of climate change on ozone and $PM_{2.5}$ air quality)





➢Additional annual costs of $9.3 billion will be required to offset impacts of climate change on air quality in 2050 for six regions and five cities (Atlanta, Chicago, Houston, Los Angeles and New York) in the U.S. (Liao et al., J AWMA, 2010)

Conclusions

➢ Development of climate-responsive air quality management strategies are fundamentally risk assessment and management processes.

➢ Managing the risks of air quality related to climate change involves assessing the climate change impacts, selecting potential air quality management options, determining air quality targets and, finally, identifying optimal air quality management strategies.

➢ Main challenge for developing climate-responsive air quality management strategies relates to the level of uncertainty associated with climate change forecasts, which makes it difficult to predict the impacts of climate change on air quality.