Challenges in Evaluating Health Impacts from Large-scale Climate and Air Pollution in Asia

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Ongoing research and challenges

- Regional to urban scale characteristics and uncertainties in large-scale analysis
  - Shortage of measurement data
  - Uncertainty of precursor emissions
  - Impacts of large-scale climate (monsoon system and mid-latitude cyclones etc.)
  - Urban photochemistry

- Challenges in current & future evaluations

Source: The New York Times
Extreme shortage of monitoring data in China

- Exceeding 75 ppb -- US EPA 8-h standard
- highly polluted & densely populated
- Basin feature (terrain <200m)
- Extreme shortage of surface monitoring
  - EANET
  - Research sites
  
  \[ \text{Lin et al., 2009, ACP} \]

Public \( O_3 \) monitors

- US: >1000!
- China: 0!
How can satellites and models inform Chinese emissions?

Lin et al. (2008a), AE
Ground-level ozone exhibits summer minimum

US and EU:
- Heat $\rightarrow$ Ozone
- $O_3$ is summertime problem

East Asia:
- Peak in spring or early summer
- Minimum in July & August
- Impacts of large-scale climate

Lin et al. (2009), ACP
Ozone seasonality in northern China and Okinawa island

Limitation of large-scale model to accurately simulate monsoon clouds

Overprediction of summertime $O_3$ by ~20 global models (Fiore et al. 2009)

Lin et al. (2009), ACP
Coupling regional and global models

Large-scale global met. reanalysis data

Climate downscaling

Regional climate model (WRF)

Online

Global CTM: MOZART (1.9)

Regional CTM: WRF-Chem: 36km

CO emissions (03/2001) [mol/km²/h]
Outflow of Asian Pollution to the Pacific
Regional characteristics of emissions, climate, and transport processes

• Models generally underestimate Asian emissions
  - Missing of activity data in rural areas
  - Possible error of emissions factor

• Significant impacts of large-scale climate
  - Summer minimum
  - Large-scale models tend to overestimate summertime $O_3$
  - Large-scale models tend to underestimate the transpacific transport of Asian pollution

• Build-up of ground-level ozone and urban chemistry
An elevated-O₃ episode is generally associated with stagnant weathers, anti-cyclonic / high-pressure systems & heat waves.

Lin et al. (2009), ACP
Role of diurnal BL processes and urban chemistry

- Intensified diurnal variation of ground-level O₃ at rural & urban areas
- Nighttime depletion of O₃ by freshly emitted NOx
- Role of boundary layer fluctuations and vertical mixing

Lin et al. (2009), ACP
Challenges and research opportunities

What we know:

- Regional to urban scale characteristics of emissions, chemistry, transport & land-atmosphere interactions strongly affect ground-level ozone exposure and hence ozone-related health outcomes.

Good news:

- Emerging high-resolution regional models (CMAQ & WRF-Chem) show some ability to capture most of these fine-scale features.

Road forward:

- These regional characteristics should be considered in assessing current and future health impacts of air pollution and climate change in Asia.

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