Interactions of Asian monsoon and regional air quality – Synergy between MICS-Asia and ACAM

Zhining Tao – USRA/GSFC-NASA

Mian Chin – GSFC-NASA
What is MICS-Asia

• Model Inter-Comparison Study for Asia

  - long-range transport and deposition of sulfur

• Phase II (2002 – 2008)
  - consider more species, e.g., S, N, O₃, aerosols...

• Phase III (2010 – 2019)
  - identify model uncertainties/improvements
  - develop reliable anthropogenic emission inventory
  - evaluate aerosol-weather-climate interactions

• Phase IV (2020 ~ ?)
Who contributes to MICS-Asia

• > 20 institutes from 12 countries and regions
• 14 CTM – 13 regional and 1 global – in Phase III

4th Atmospheric Composition and Asian Monsoon Workshop, UKM, Malaysia, June 26-28 2019
What are goals of ACAM

• Emissions and air quality in the Asian monsoon region
• Aerosols, clouds, and their interactions with the Asian Monsoon
• Impact of monsoon convection on chemistry
• UTLS response to the Asian monsoon

- Quoted from http://www.ukm.my/acam/

Quite overlaps between goals of MICS-Asia and ACAM
Science questions:

• How do pollution and dust aerosols regulate the circulation and rainfall via scattering and absorbing solar radiation, changing the atmospheric heating rates, and modifying the cloud properties?

• How do these meteorology changes feedback to regional air quality?
Regional model NU-WRF experiments

- Domains 1~3 follow MICS-Asia with 45-, 15-, and 5-km horizontal resolution for year 2010
- White dots (EANET sites), black dots (AERONET sites)
- In d03 (North China Plain), diamonds for CERN air quality monitoring sites; black dots for CMA meteorological stations
Comparison with daily mean meteorology from CMA

**Temperature**
- $R = 0.99$
- RMSE = 2.02
- Bias = -0.64

**Wind**
- $R = 0.75$
- RMSE = 1.67
- Bias = 1.41

**Relative Humidity (RH)**
- $R = 0.67$
- RMSE = 13.3
- Bias = -7.73

**Precipitation**
- $R = 0.52$
- RMSE = 5.84
- Bias = 1.53
Comparison with daily mean air quality from CERN

Overestimate of O$_3$ and PM2.5 but underestimate of CO and NOx
## Sensitivity Experiments

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Feedback(s) included</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>No aerosol-microphysics-radiation interactions</td>
</tr>
<tr>
<td>AM</td>
<td>Aerosol-microphysics interaction only</td>
</tr>
<tr>
<td>AR</td>
<td>Aerosol-radiation interaction only</td>
</tr>
<tr>
<td>AMR</td>
<td>Aerosol-microphysics-radiation interactions</td>
</tr>
</tbody>
</table>

\[
\text{AM effect} = \text{AM} - \text{None} \\
\text{AR effect} = \text{AR} - \text{None} \\
\text{AMR effect} = \text{AMR} - \text{None}
\]

\[
\text{AMR effect} \neq \text{AM effect} + \text{AR effect}
\]
Impact of aerosols on key meteorology

Monthly average from d03 (Red = AMR on; Blue = aerosol-mircophysics interaction (AM) on; Orange = aerosol-radiation interaction (AR) on; Black = no AMR)

Increase in Winter

Decrease in Summer

5% reduction > 10% in winter

< 0.2 K change

4% reduction

36% reduction

10% reduction

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Impact of aerosols on regional air quality

2% increase

6% increase

4% increase

Increase in Summer

Decrease in Spring

Barely changed
Summary

• Modeling of 2010 air quality over eastern Asia shows NU-WRF having sufficient skill in simulating daily to monthly aerosols and trace gases as compared to the available from ground- and space- measurements.

• Aerosol-microphysics-radiation interactions have sizeable impacts on local meteorology, e.g., SW radiation, temp., wind, cloud, PBLH, and precipitation

• Increase primary pollutant (i.e. CO, NOx, SO₂) conc. mainly due to reduced PBLH

• Slightly change PM2.5 in winter, reduce it in spring, and increase it summer, related to precipitation?

• Impact on ozone is minimum largely due to the contradicting meteorological conditions induced by aerosols
Synergy between MICS-Asia and ACAM

• Common goals between two programs (AMRI, air quality, emissions, radiative forcing, etc.)
• Both programs rely on data and modeling
• Promote data sharing
• Coordinate modeling activities beneficial to both communities
• Prepare for geo-satellite composition observing era over the region, i.e., GEMS
• More?