International Conference on Transboundary Air Pollution in North-East Asia

Modeling study on relationships between regional emissions and secondary inorganic aerosol in Tokyo

Hiroshi HAYAMI

Central Research Institute of Electric Power Industry

Copyright 2008 CRIEPI. All rights reserved.

Introduction: $PM_{2.5}$ levels in Japan

- Roadside $PM_{2.5}$ decreasing
- Urban & rural $PM_{2.5}$ stay constant around WHO AQ guideline & US AQ standard.

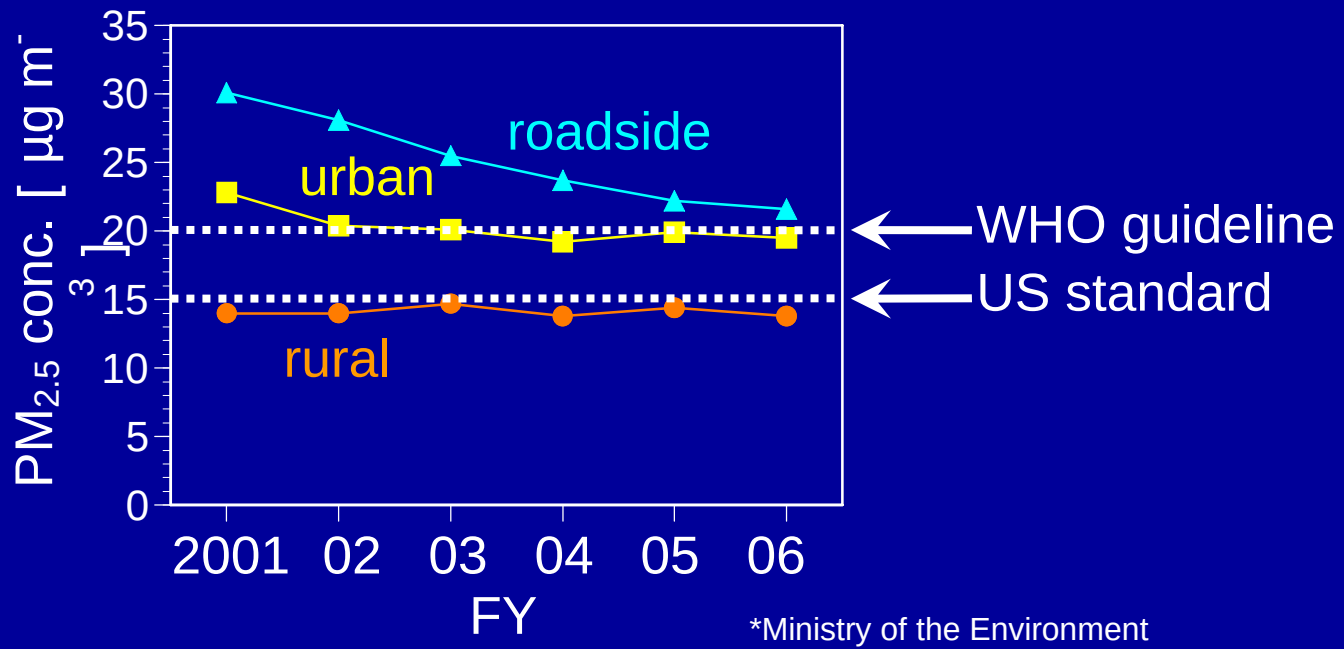
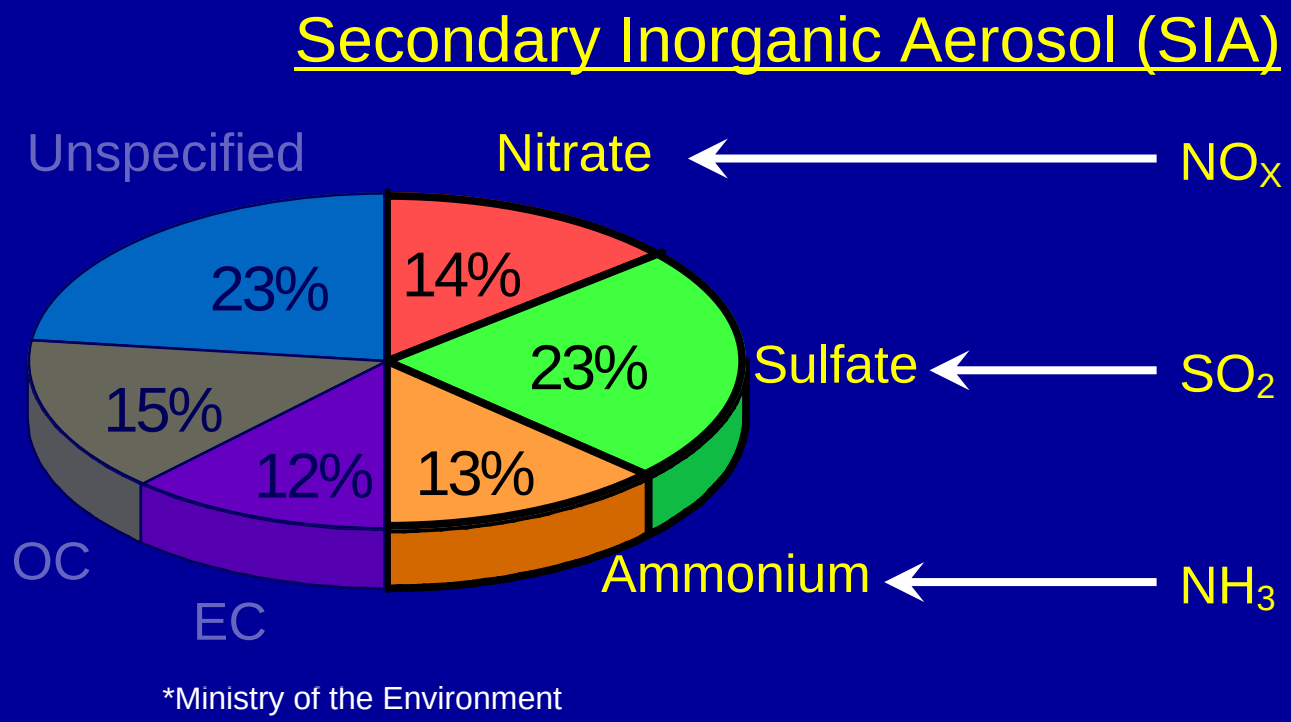


Fig. Annual trend of PM2.5 in Japan

Copyright 2008 CRIEPI. All rights reserved.

Chemical composition of $PM_{2.5}$



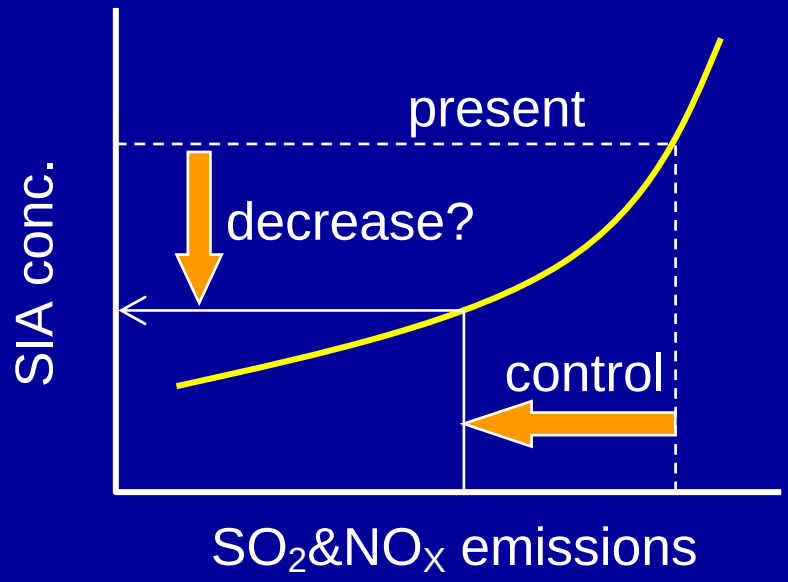
*Ministry of the Environment

- >50% comes from NO_X and SO_2
  - ammonium formed to neutralize sulfate and nitrate
  - water in “unspecified” associated with SIA

Copyright 2008 CRIEPI. All rights reserved.

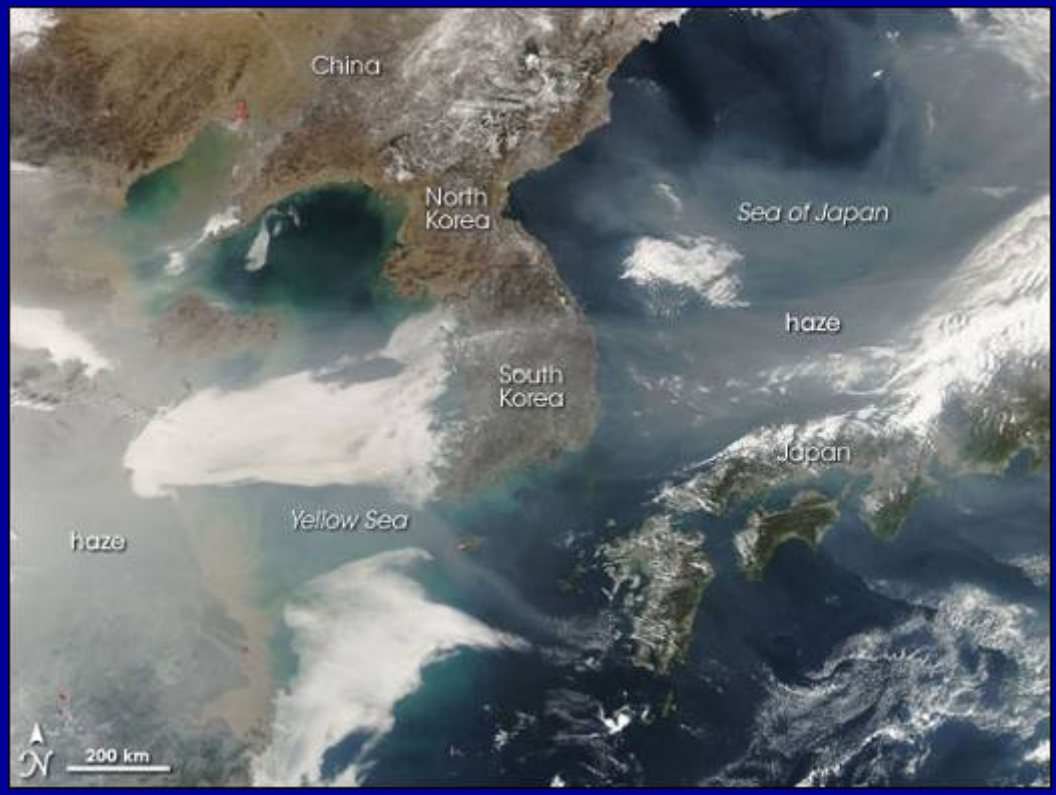
To decrease $PM_{2.5}$ in Japan

- SIA is important to decrease $PM_{2.5}$
  - more than half of $PM_{2.5}$
  - derived from SO_X & NO_X
- How're relationships b/w NO_X/SO_X & SIA?



Copyright 2008 CRIEPI. All rights reserved.

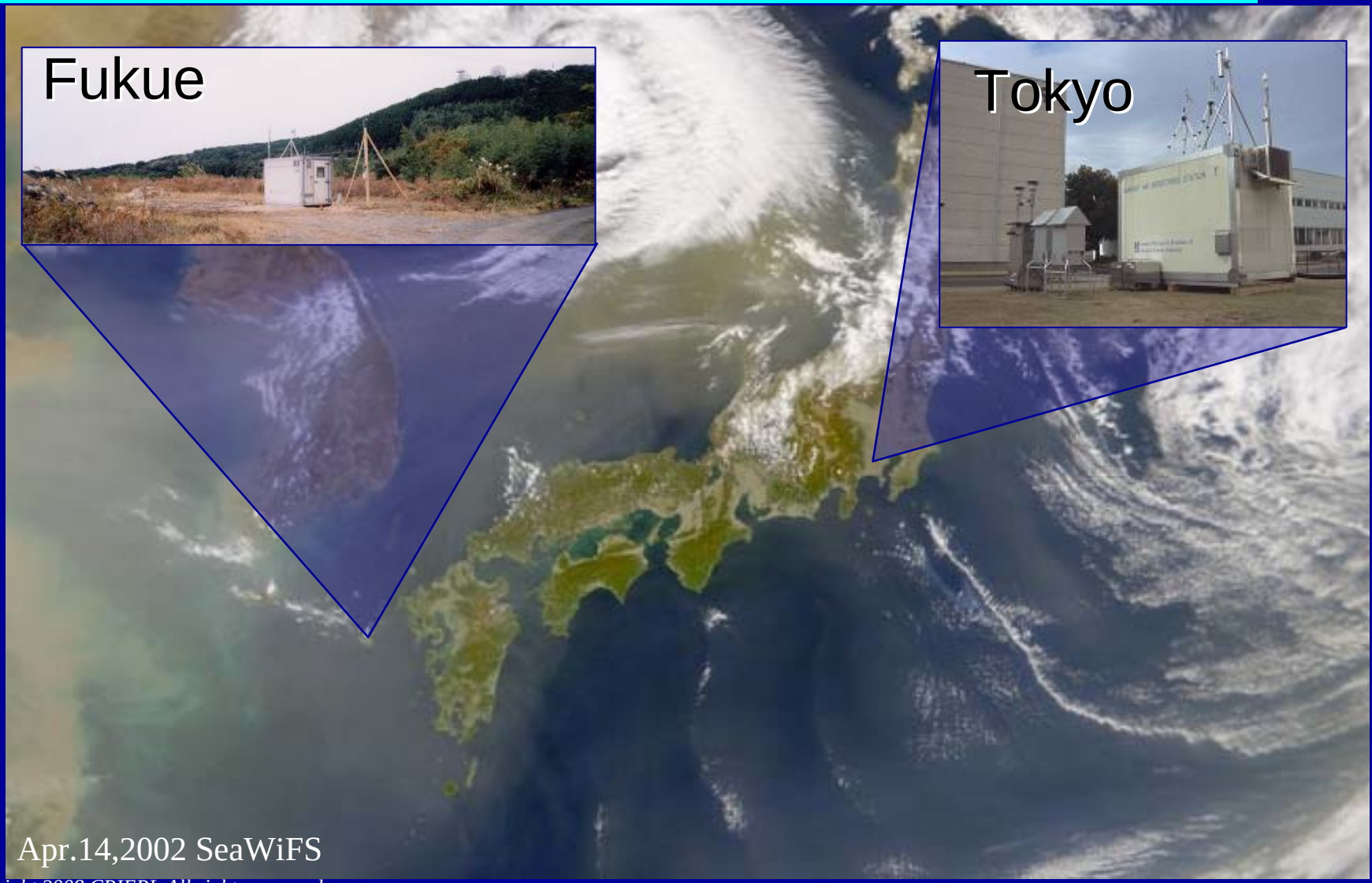
Trans-boundary PM pollution



- Distant emissions may influence SIA/$PM_{2.5}$

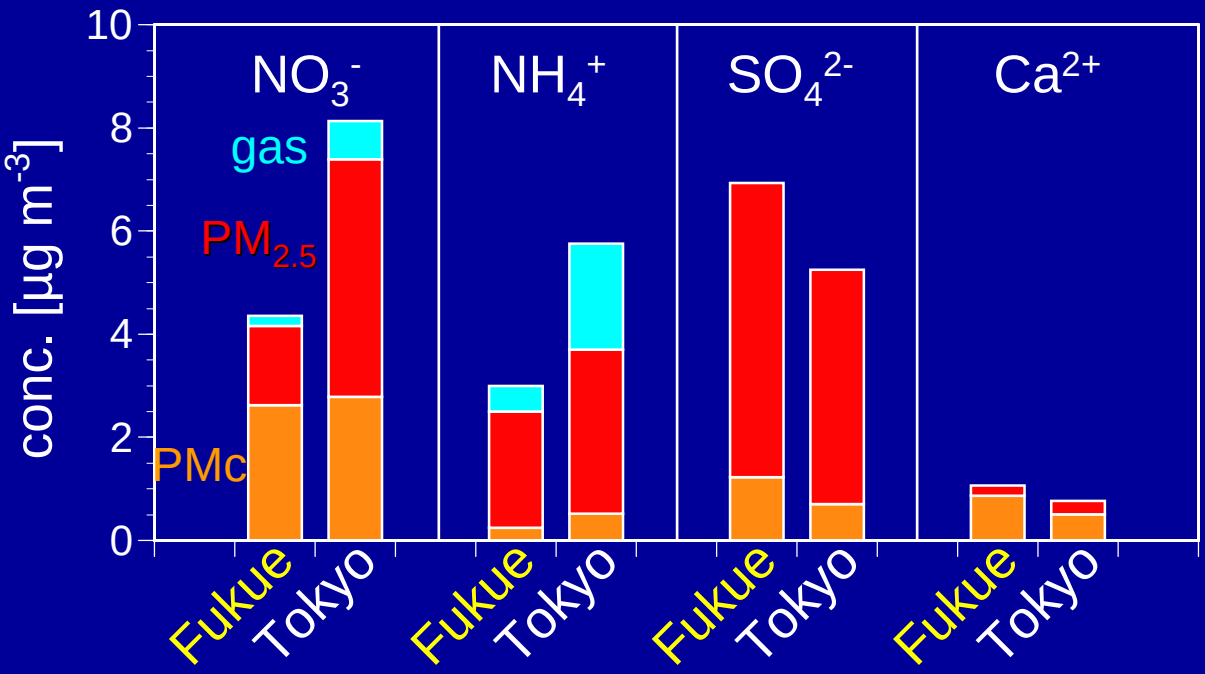
Copyright 2008 CRIEPI. All rights reserved.

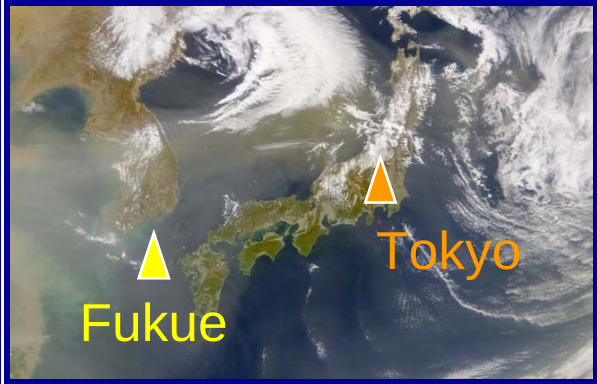
Simultaneous monitoring of SIA



Copyright 2008 CRIEPI. All rights reserved.

Springtime avgs in 2000 to 2002



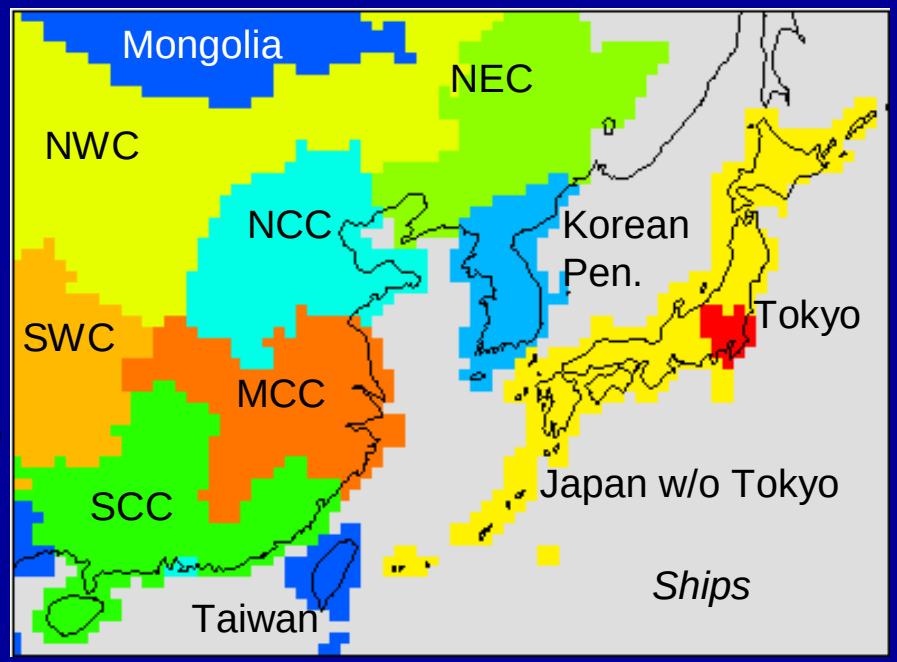


- $PM_{2.5}$ nitrate: [Tokyo] >> [Fukue]
- $PM_{2.5}$ sulfate: [Tokyo] << [Fukue]

Copyright 2008 CRIEPI. All rights reserved.

Modeling study

- Sensitivity of SIA in TKY to regional emissions
  - East Asia
  - 12 source regions
  - +20% emissions
    - ~growth in three years
  - changes in SIA in Tokyo
    - air quality model
    - whole-year simulations



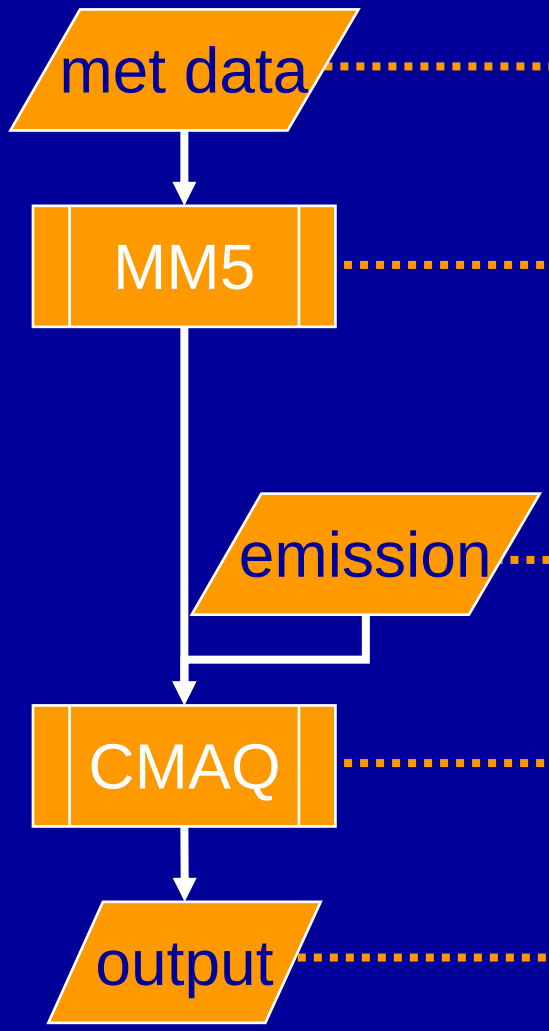
Copyright 2008 CRIEPI. All rights reserved.

Air quality model

- CMAQ (Community Multiscale Air Quality)
  - developed by US EPA
    - latest version 4.7 released in Nov., 2008
    - many users in US, Asia, Japan…
  - comprehensive 3D Eulerian model
    - emission, advection/diffusion, chemical reactions, cloud process, deposition

Copyright 2008 CRIEPI. All rights reserved.

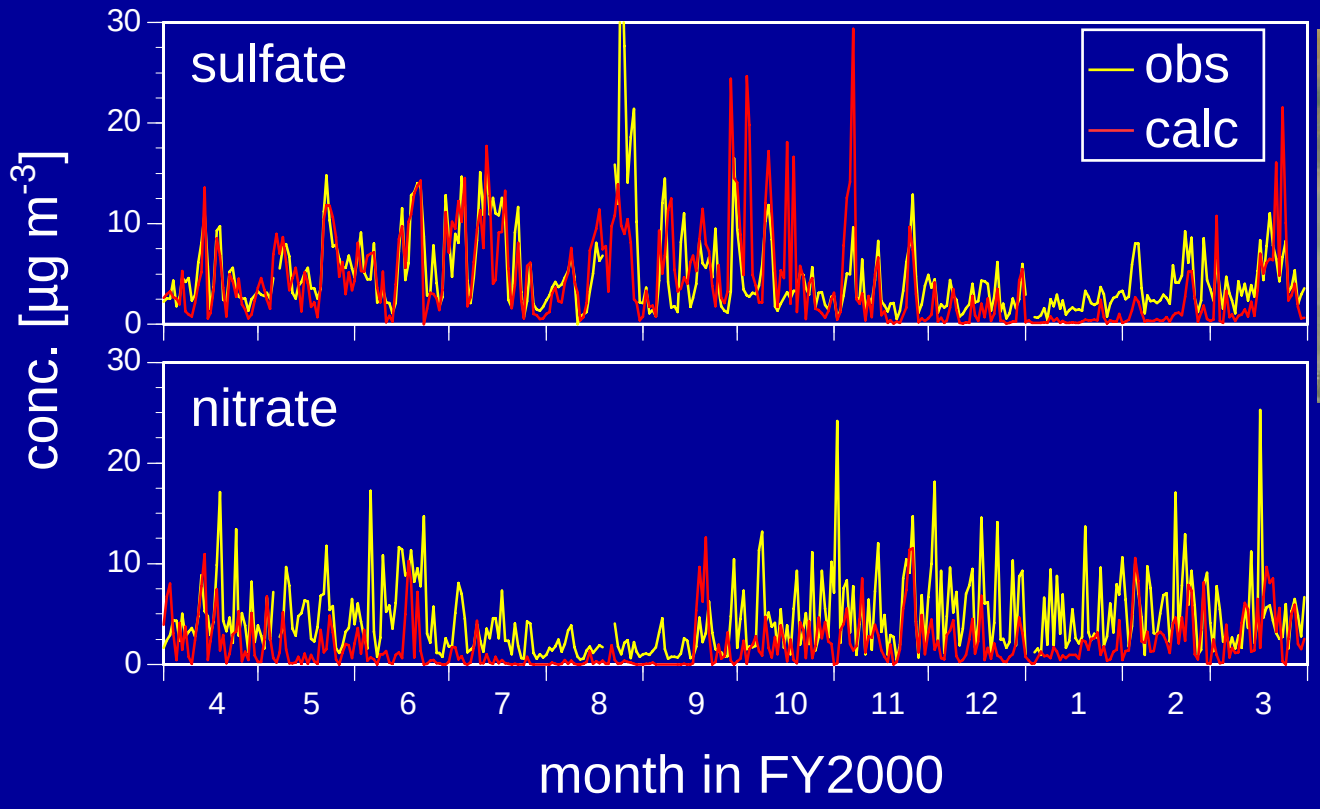
Simulation method

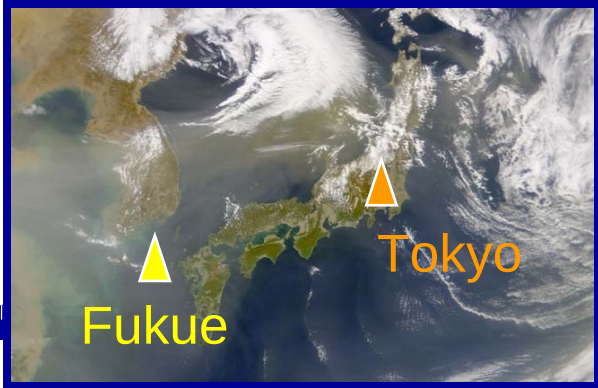


- objectively analyzed data
  - US NCEP FNL (1 deg., 6 hr)
- meteorological model
  - V3.7-1 developed by US NCAR
- emission maps
  - MICS-Asia (0.5 deg., monthly)
- air quality model
  - V4.5
- concentration & deposition fields
  - every hour in FY2000

Copyright 2008 CRIEPI. All rights reserved.

Model performance: Tokyo

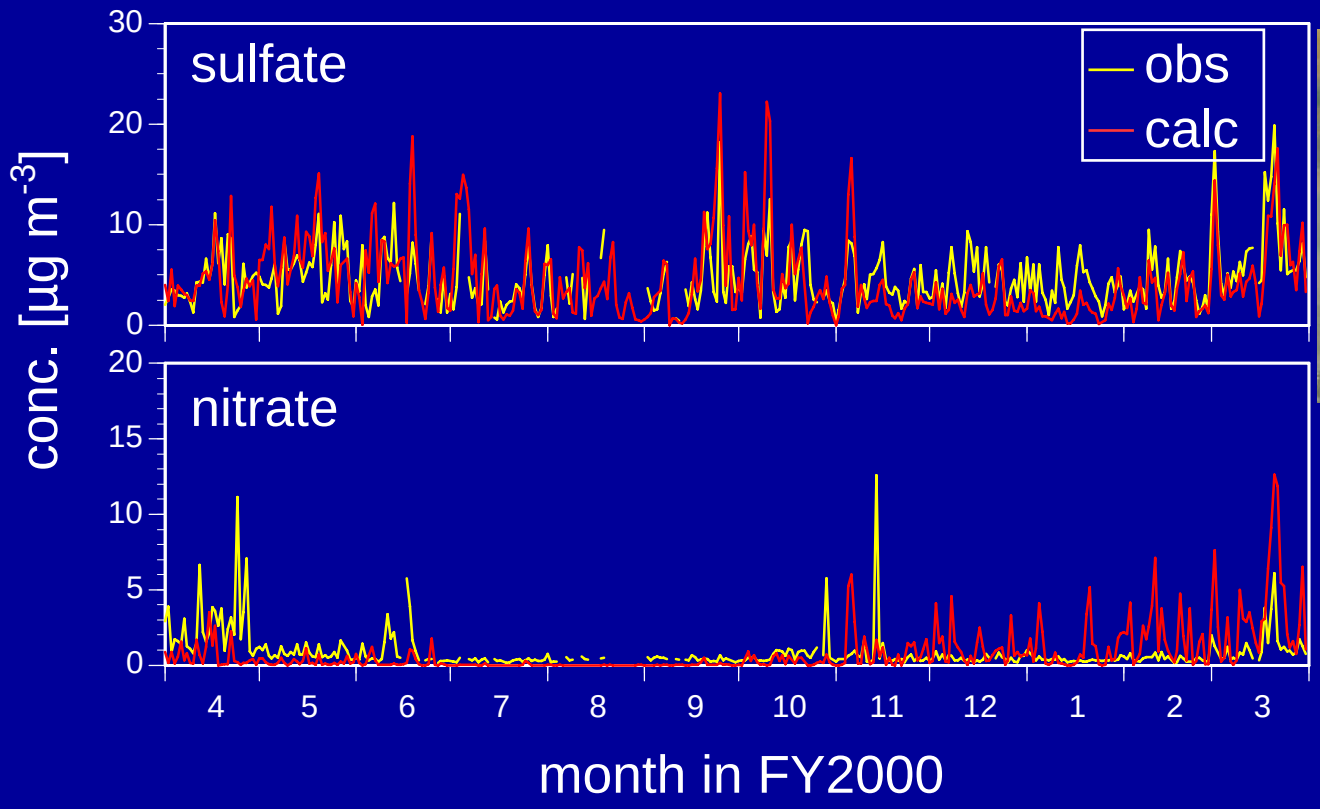


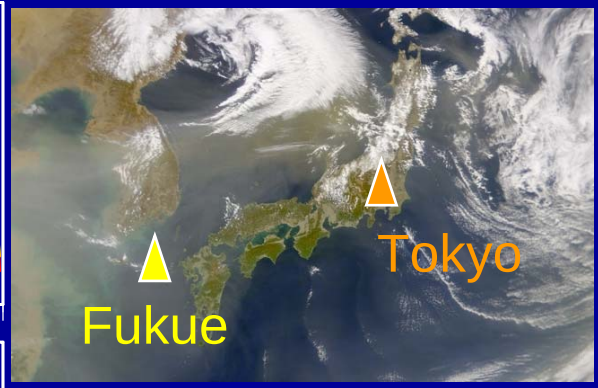


- good for sulfate, underestimating for nitrate

Copyright 2008 CRIEPI. All rights reserved.

Model performance: Fukue

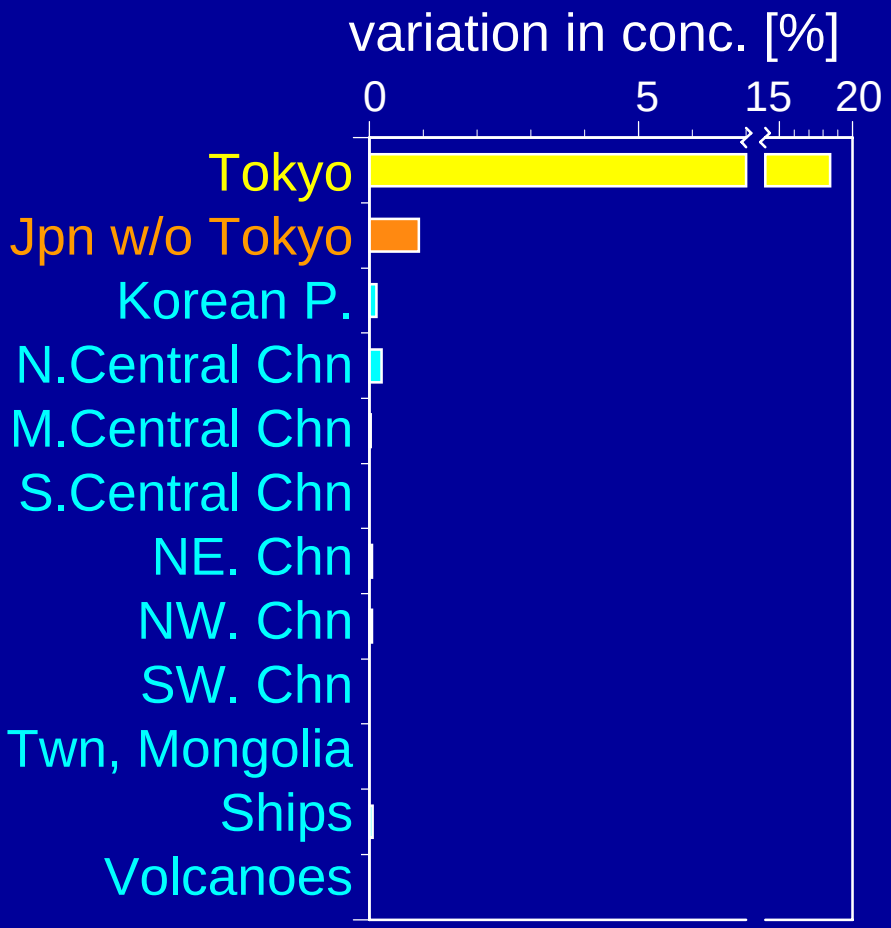




- good for sulfate, over and under for nitrate

Copyright 2008 CRIEPI. All rights reserved.

Annual changes in Tokyo (SO_2)

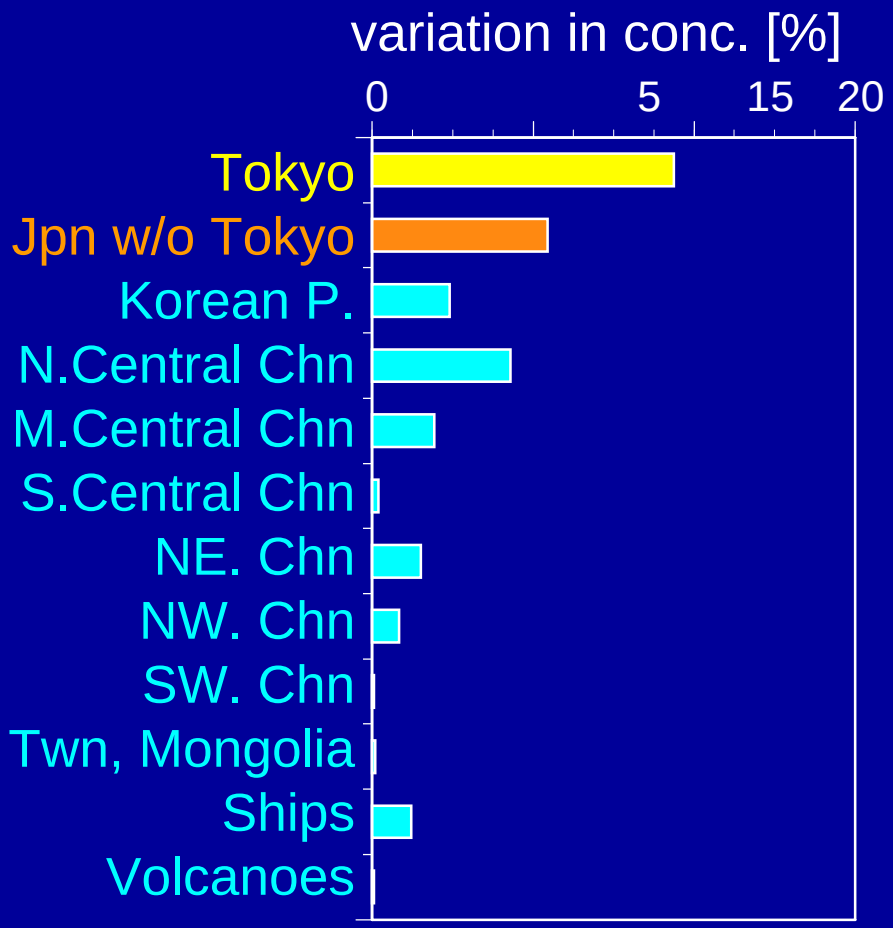


- Local emissions 20%↑
  - →SO_2 in TKY 18.5%↑
- Domestic emiss. 20%↑
  - →SO_2 in TKY 0.9%↑
- Foreign emiss. 20%↑
  - →SO_2 in TKY <0.4%↑

- Large local contribution
  - primary pollutant

Copyright 2008 CRIEPI. All rights reserved.

Annual changes in Tokyo (sulfate)

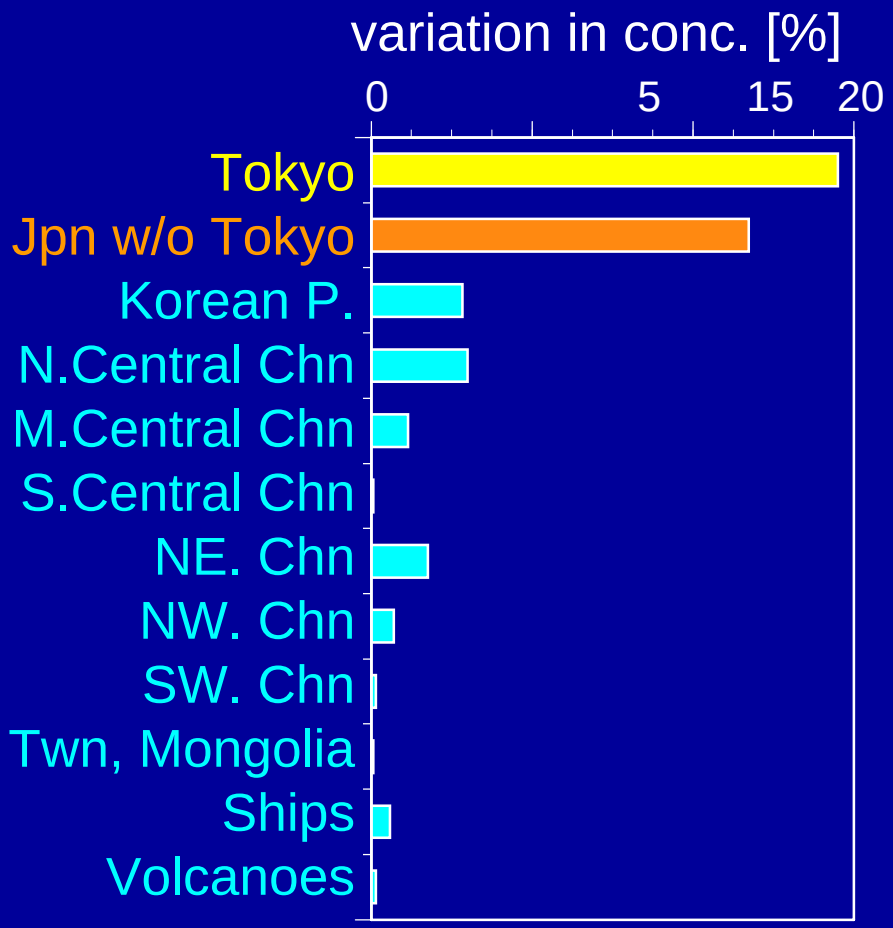


- Local emissions 20%↑
  - →SO_2 in TKY 3.8%↑
- Domestic emiss. 20%↑
  - →SO_2 in TKY 2.2%↑
- Foreign emiss. 20%↑
  - →SO_2 in TKY 6.8%↑

- (local+domestic)~foreign
  - secondary pollutant
  - long-rage transport

Copyright 2008 CRIEPI. All rights reserved.

Annual changes in Tokyo (nitrate)



- Local emissions 20%↑
  - →SO_2 in TKY 5.8%↑
- Domestic emiss. 20%↑
  - →SO_2 in TKY 4.7%↑
- Foreign emiss. 20%↑
  - →SO_2 in TKY 4.4%↑

- local~domestic~foreign
  - faster than sulfate
  - transported as aerosol

Copyright 2008 CRIEPI. All rights reserved.

Summary

- 20% increase in local & domestic emissions
  - sulfate in Tokyo: +6%
  - nitrate in Tokyo : +10%
- 20% increase in foreign emissions
  - sulfate in Tokyo : +7%
  - nitrate in Tokyo : +4%

- Caution: nonlinearity

Copyright 2008 CRIEPI. All rights reserved.