
Sensitivity of Secondary Inorganic Aerosol in Greater Tokyo to Foreign and Domestic Emissions

Hiroshi HAYAMI
CRIEPI

Time flies...



Second, July 22-23, 1999

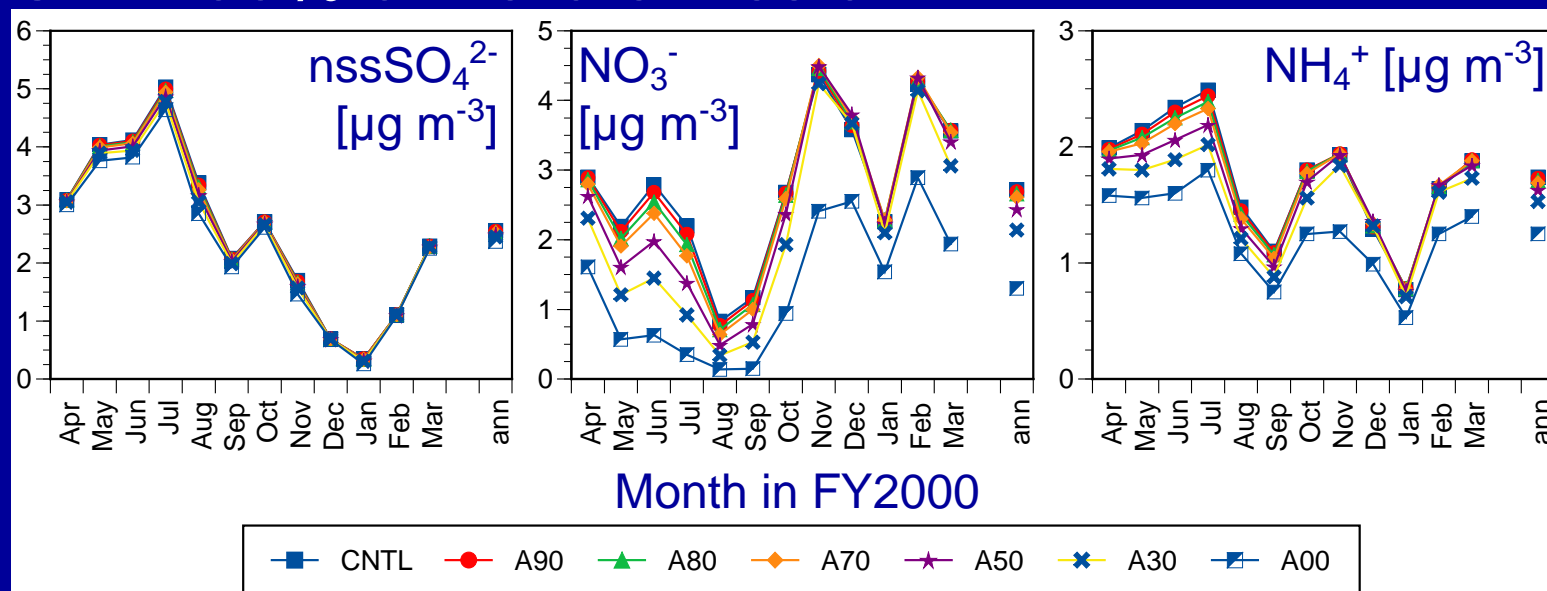


Third, September 18-19, 1999

Last year...

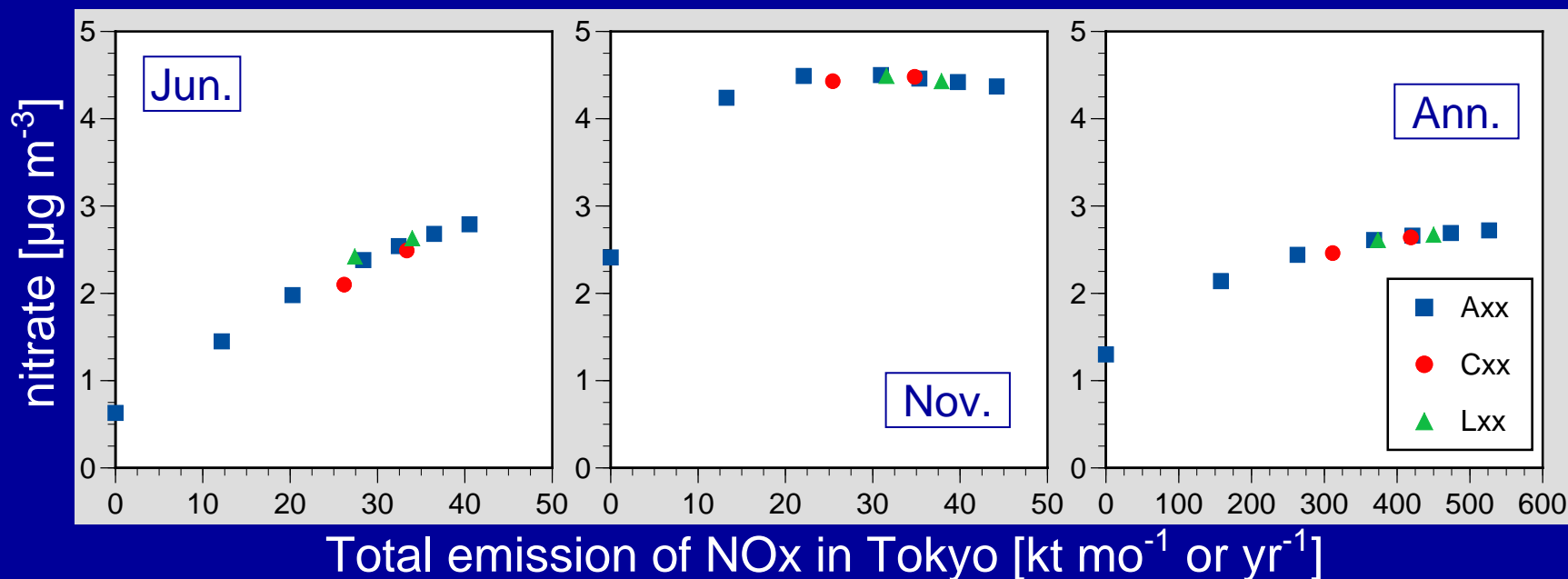
◆ How effective emission reductions in Tokyo are to SIA concentrations in Tokyo

- ▶ sulfate: very little change
- ▶ nitrate: -41% at zero emission
- ▶ SIA: -30% at zero emission



Non-linearity

- ◆ Non-linear b/w NO_x emissions in Tokyo and nitrate in Tokyo
- ◆ Markus's comment
 - ▶ Non-linearity canceled at country/regional scales



Today...

◆ Sensitivity of emission changes in East Asia to SIA in Tokyo

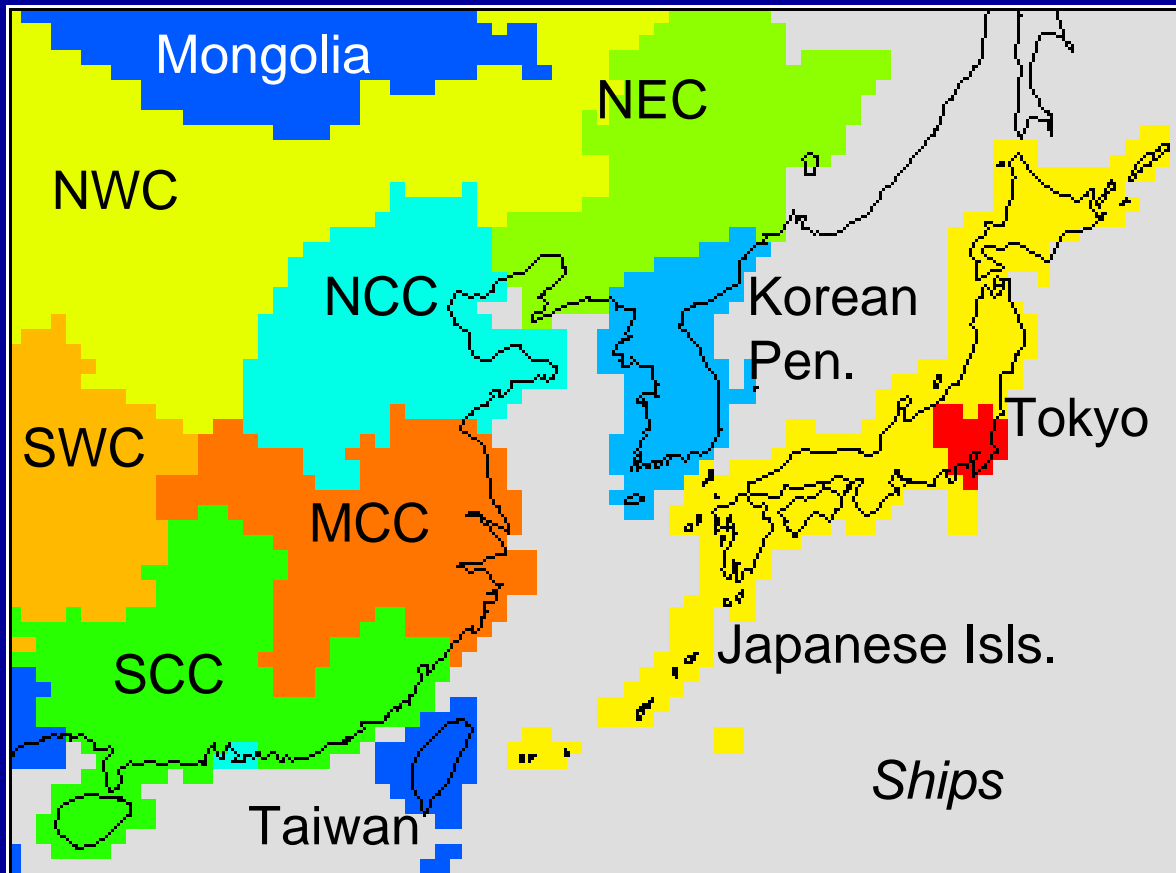
▶ simulations

- 12 source regions in East Asia
- +20% emissions in each region
- one-year simulations with MM5/CMAQ

▶ analysis

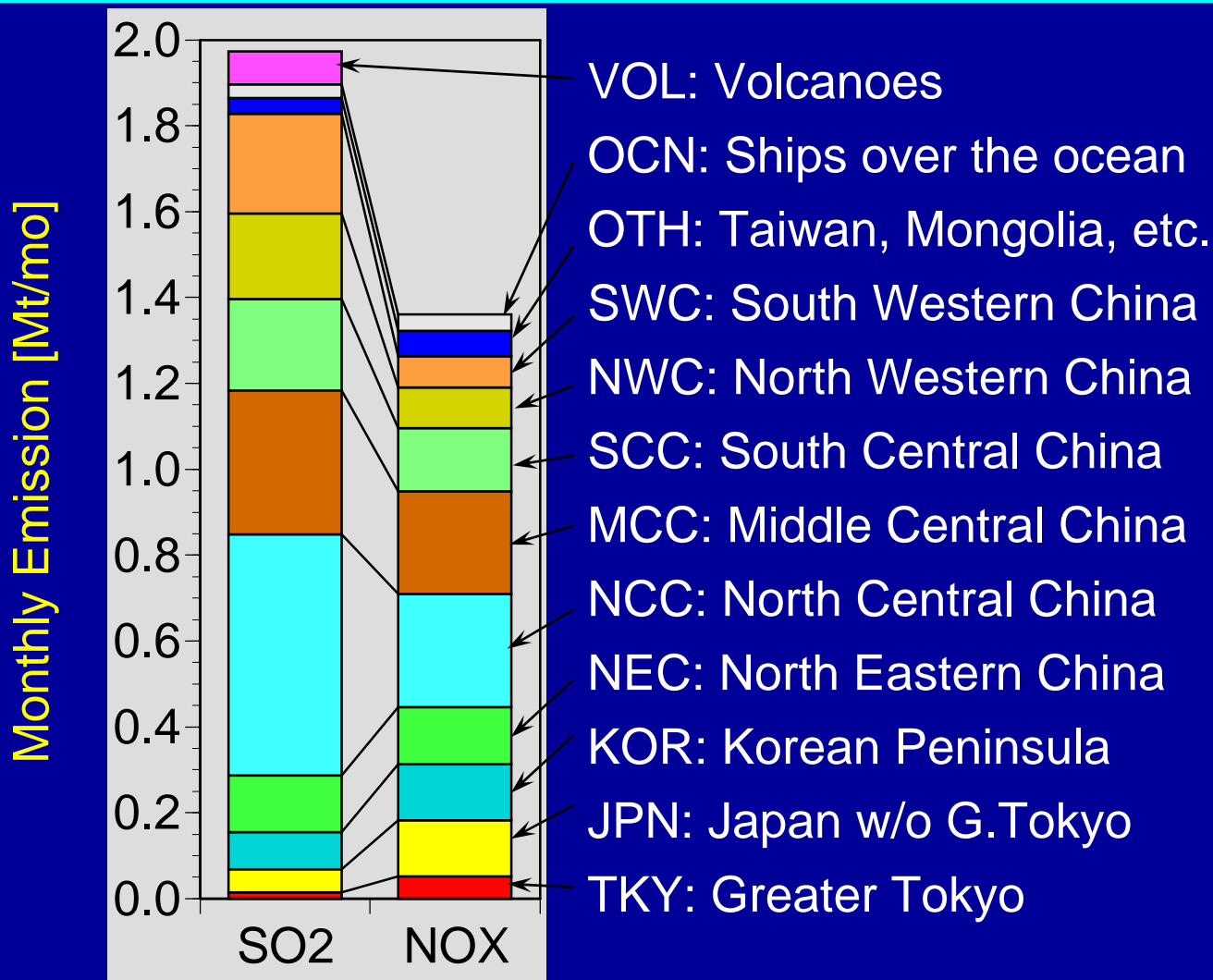
- sensitivity: SIA response (R_i [%]) = $C_{i+20\%} / C_{CNT} - 1$
- linearity: $\sum R_i$ vs. R_{ALL} (= all emissions +20%)
- linearity: $R_{i+20\%}$ vs. $R_{i-20\%}$

12 source regions

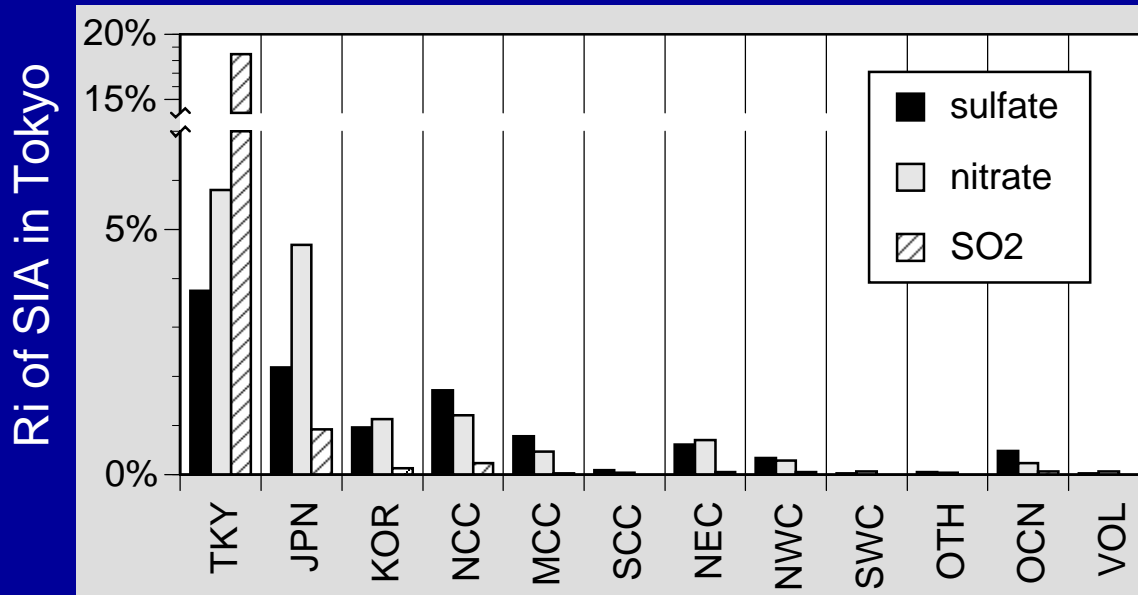


- TKY: Tokyo
- JPN: Japanese Isls.
- KOR: Korean Pen.
- NEC: NE China
- NCC: N Central China
- MCC: Middle C China
- SCC: South C China
- NWC: NW China
- SWC: SW China
- OCN: Ships
- VOL: Volcanoes
- OTH: Taiwan, Mongolia, SE Asia

Emissions from source regions

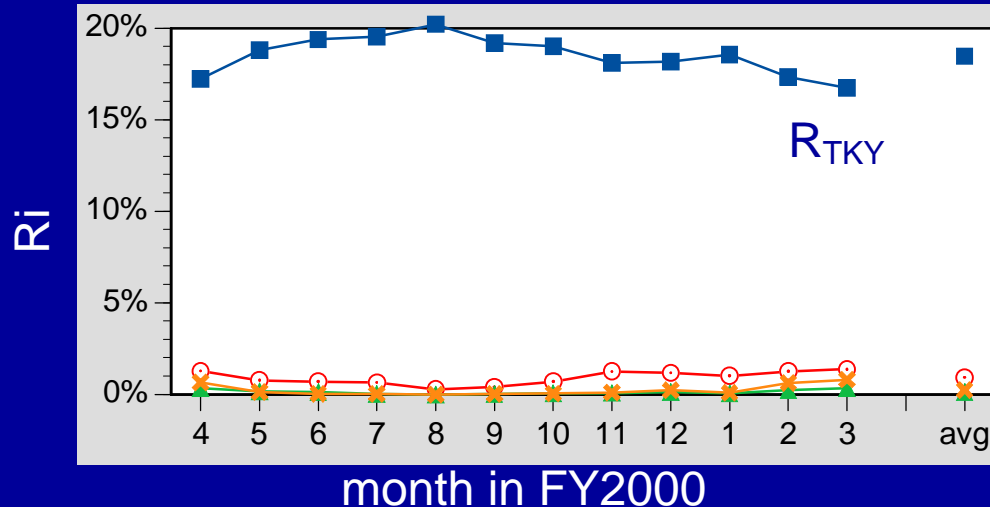


Sensitivity of SIA to +20% emis.



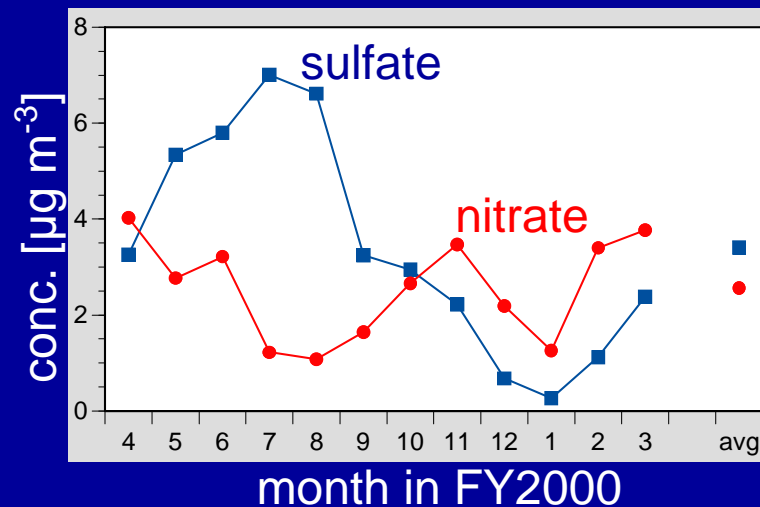
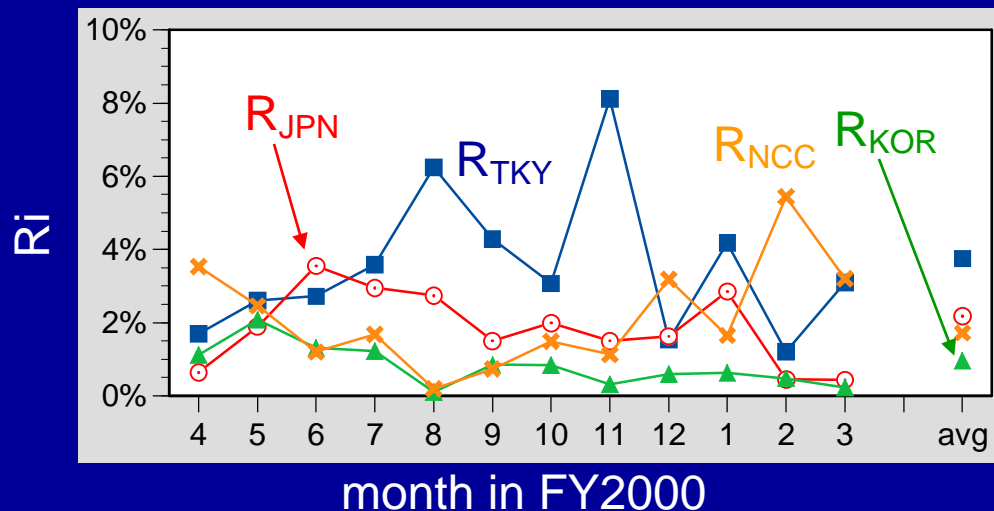
- ◆ SIA in Tokyo is most influenced by Tokyo
 - ▶ followed by JPN, NCC, KOR...
 - ▶ nitrate more locally than sulfate
 - ▶ (SO₂ controlled by local emissions)

Monthly Changes: SO₂



- ▶ SO₂ increased by ~20% to +20% local emissions
 - SO₂ mostly controlled by local emissions
 - simulations done correctly

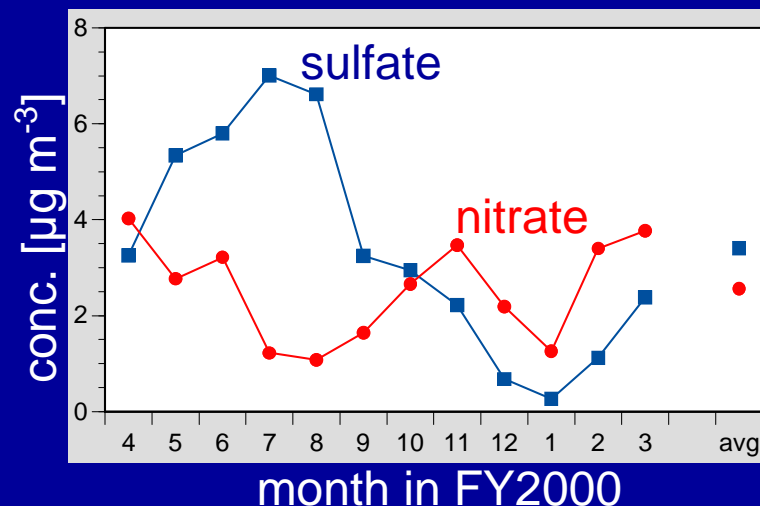
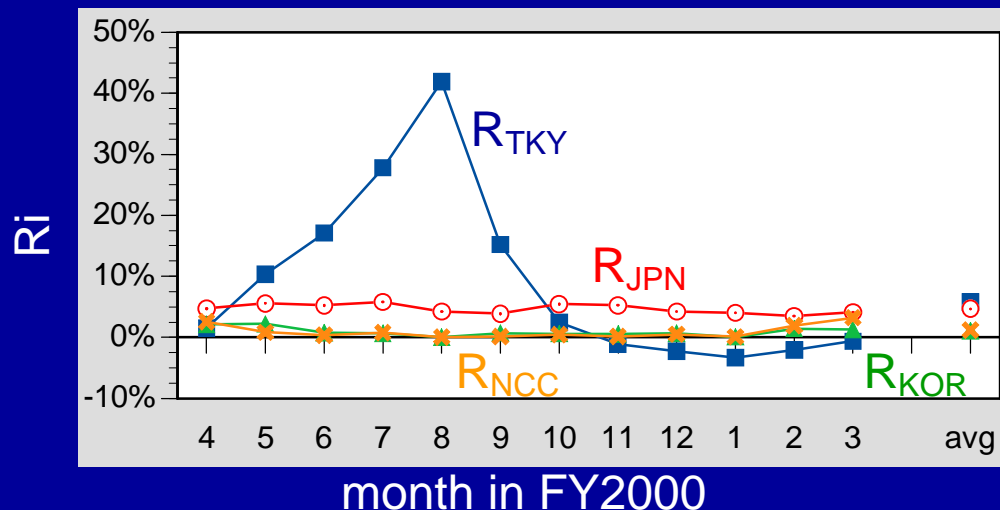
Monthly Changes: sulfate



▶ seasonal variations

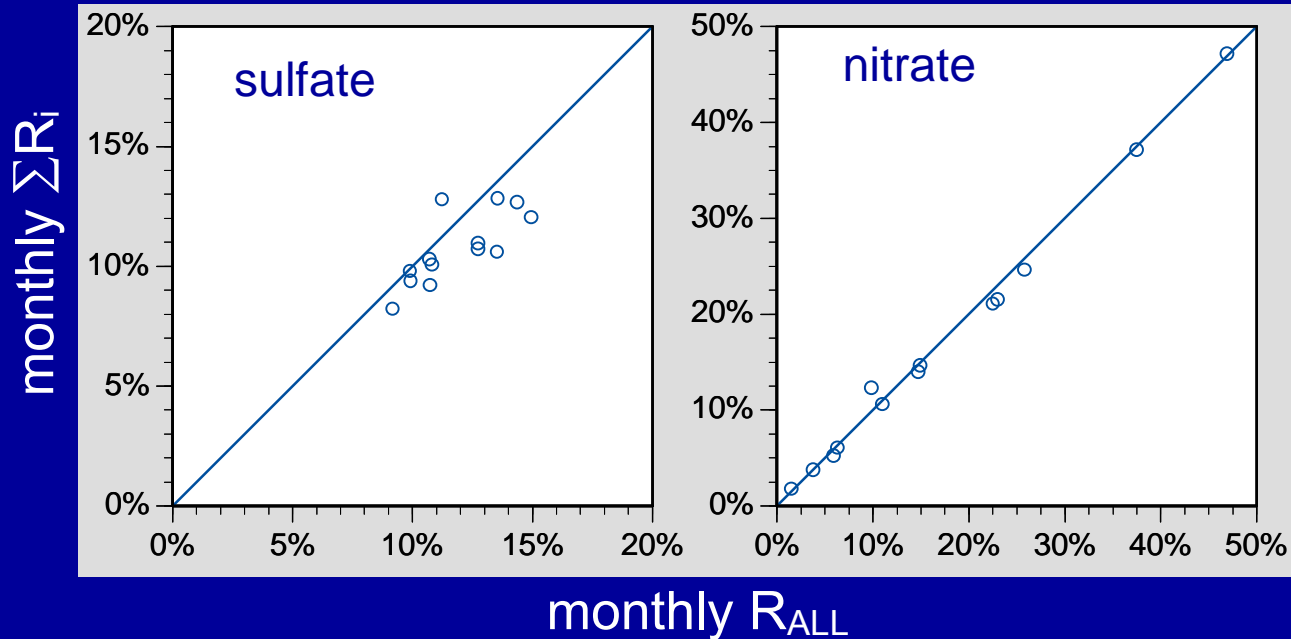
- NCC changes most in springtime
- domestic sources changes most in summertime, when concentrations are highest.

Monthly Changes: nitrate



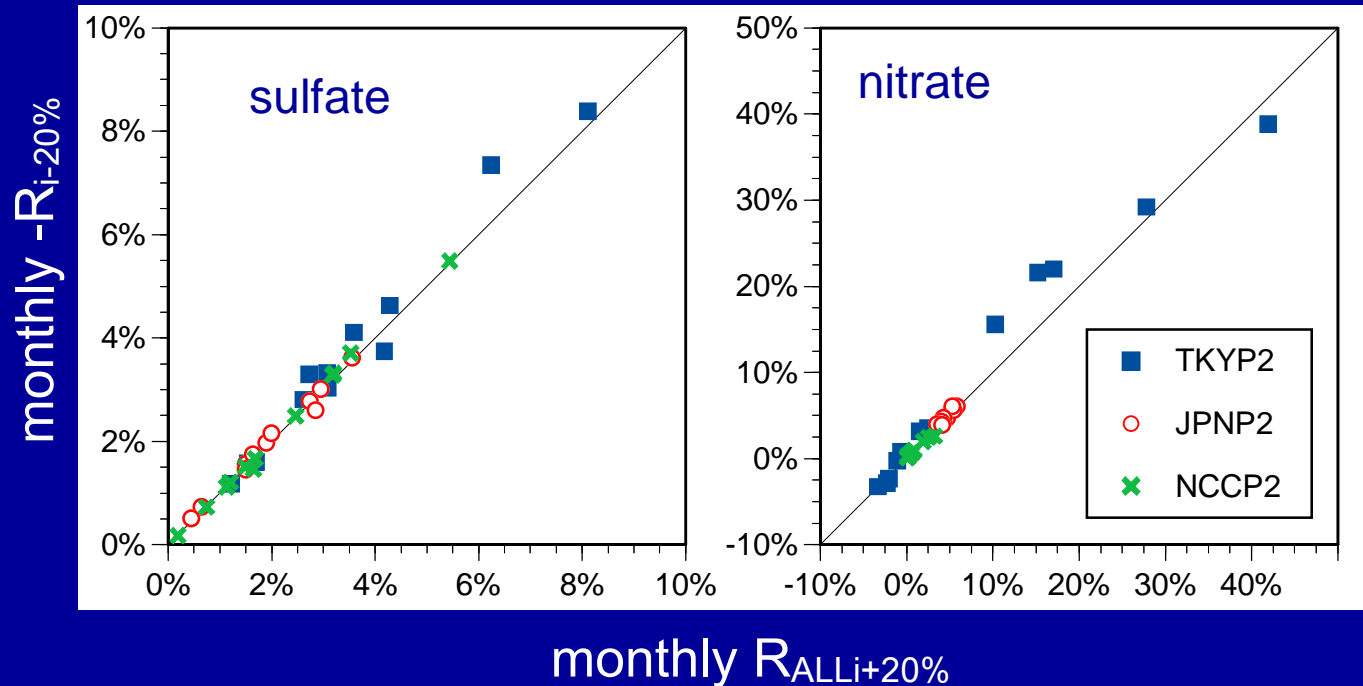
- ▶ $R_{TKY} > 20\%$ in summertime
 - R_{TKY} of total nitrate $\sim 14\%$
 - ammonia also emitted at $+20\%$
 - particulate-to-total nitrate ratio increased much
- ▶ $R_{TKY} < 0\%$ in wintertime
 - $\text{NO} \nearrow$ leads to $\text{O}_3 \searrow$ followed by nitrate \searrow

linearity: $\sum R_i$ vs. R_{ALL}



- ▶ sulfate: $\sum R_i$ is smaller than R_{ALL} by 14%
- ▶ nitrate: $\sum R_i = R_{ALL}$, suggesting linearity?
 - note: $\sum R_i$ includes negative R_{TKY}

linearity: $R_{i+20\%}$ vs. $R_{i-20\%}$



- ▶ For distant sources, $R_{i+20\%} = -R_{i-20\%}$
- ▶ For local sources, $R_{i+20\%} \neq -R_{i-20\%}$

Summary

- ◆ SIA in Tokyo responds to emissions in Tokyo
 - ▶ followed by JPN, NCC and KOR
 - ▶ distant sources influence in springtime
- ◆ Linearity
 - ▶ some errors induced in S/R estimates by assuming linearity
 - ▶ linearity approximated in sensitivity analysis for distant sources

Further work

- ◆ How about other changes than 20%?
- ◆ How about changes in only burning sources?
 - ▶ in the present study, all emissions from burning and non-burning sources changed