A feasibility study for the monitoring of diurnal variations of tropospheric NO₂ over Tokyo from a geostationary satellite

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Abstract

We have conducted a feasibility study for the monitoring of diurnal variations of anthropogenic nitrogen dioxide (NO₂) in the lower troposphere over Tokyo, Japan, assuming a geostationary satellite’s measurement. The retrieval simulation showed that the total NO₂ slant column (SC) density (2.5-4.5 \times 10^{16} \text{ cm}^{-2}, depending on local time and season) could be measured with a precision of 10-20% at signal-to-noise ratio (SNR)=200 and 1-2% at SNR=2000, respectively. In our estimation, the precision of the SC did not strongly depend on local time (LT5-18 in summer and LT7-16 in winter) or season (summer and winter). We found that the diurnal variation of total NO₂ SC density from morning to evening (the magnitude is about 1.0 \times 10^{16} \text{ cm}^{-2}) could be well detected by a sensor with SNR>500. The detection of a local minimum appearing at summer noon (0.5 \times 10^{16} \text{ cm}^{-2}) needs better precision (SNR>1000).

Results – Precision and Bias of Slant Column Retrievals

**Diurnal variation of SC**

- Diurnal variation of SC: ~10^{16} \text{ cm}^{-2}, detectable with SNR>500.
- Local minimum in summer afternoon: 0.5 \times 10^{16} \text{ cm}^{-2}, detectable with SNR>1000.
- SC (i.e., air mass factor) depends significantly on wavelength in the fitting window (425-450nm).

**Relative precision of SC retrieval**

- Precision of total SC is 10-20% for SNR200 and 1-2% for SNR2000.
- Use of \(\sigma\) at 223K or 293K causes a bias of 0.2-0.3 \times 10^{16} \text{ cm}^{-2}.
- Precision of SC has small dependency on local time and season.
- CCD sensor currently discussed has a precision of 2-4% (~SNR1000).

**Bias caused by temperature dependence of cross-section**

- Temperature dependence of absorption cross-section (\(\sigma\)) has been introduced into the RTM.
- Use of \(\sigma\) at 223K or 293K causes a bias of 0.2-0.3 \times 10^{16} \text{ cm}^{-2}.
- \(\sigma\) at lower temperature (223K) gives a better fitting results in morning and evening due to larger light path in the stratosphere.

Future work...

- Separation of the tropospheric SC from the total SC and air mass factor calculation should be examined for realistic scenario.

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