# PC2) Meteorological and Chemical Behavior of Gaseous Sulfur Compounds in and around an Urban Valley

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## 1. Introduction

Air pollutants (e.g., VOCs and reduced sulfur compounds (RSCs)) released from various emission sources in the industrialized and/or polluted urban areas are carried to nearby dwellings and communities and thus can lead to serious air pollution problems in and around those areas due to meteorological conditions and geographical features (Athanassiadis et al., 2002). Under specific meteorological conditions (e.g., a high-pressure system with low and/or closed ventilations), the high concentrations (about 120ppb) of air pollutants (e.g., $O_3$) occurred in downtown Philadelphia, Pennsylvania during July 1999 (Athanassiadis et al., 2002). On the other hand, evidences of the dispersion of odorous pollutants such as RSCs caused by the specific meteorological conditions and their impact on air quality in the downwind regions have been reported in the literatures (Lin et al., 2006; Song et al., 2008). Although measurement techniques and modeling approaches were recently improved, none of those simultaneously took into consideration both the accumulation of RSCs due to the ventilation condition and their chemical transformation around the polluted urban areas.

The objective of this study is to assess the effects of ventilation and photochemical oxidation of the RSCs on $SO_2$ concentrations in and around an urban valley. The analyses were performed based on a numerical modeling approach using the data set of RSC emission concentrations measured from several industrial source regions during the measurement period of 2008. The relative contribution of photochemical oxidation of RSCs to $SO_2$ formation in the source regions was also compared between the different ventilation conditions.

## 2. Study methods

The effects of ventilation and photochemical oxidation of RSCs on $SO_2$ concentration levels in the study area were assessed by two sets of simulation scenarios: the estimation of $SO_2$ concentrations in cases under (1) the high ventilation (HV) (i.e., the field measurement period of 21 October 2008) and (2) low ventilation (LV) conditions (i.e., 16 October 2008). Note that the model estimates of $SO_2$ with (i.e., CHEM case) and without the photochemical oxidation of the RSCs (i.e., BASE case) between the HV and LV conditions were classified as CHEM_HV and BASE_HV cases and CHEM_LV and BASE_LV cases, respectively. For the purpose of this study, the RSC emissions for the CHEM_LV case are assumed to employ the same magnitude of RSC emissions estimated for the CHEM_HV case.

For the numerical modeling for the HV and LV conditions, the abbreviated oxidation mechanisms of RSCs and the emission rates of RSCs and $SO_2$ were added to the section of chemical transformation. The $SO_2$ concentrations in the source and surrounding regions were estimated by considering both the chemical transformation (and ventilation conditions) of the RSCs and the emissions of $SO_2$. Moreover, the spatial distributions of $SO_2$ were estimated among five different regions (e.g., Yangsan (YS), Miryang (MY), Gimhae (GH), Ulsan (US), and Busan (BS)). The relative contribution of photochemical

oxidation of RSCs to $SO_2$ concentration levels in the source regions was also compared between the different ventilation conditions.

### 3. Results and Discussion

Fig. 1 shows the $SO_2$ concentrations simulated at 09:00 and 15:00 LST for the CHEM_HV and CHEM_LV cases with mostly easterly and northerly surface winds. Overall, the $SO_2$ concentrations at the surface layer depended largely on the wind speed and direction of the air inflow. The temporal and spatial distributions of $SO_2$ in the study area were significantly distinguished between the two cases.

For the CHEM_HV case, $SO_2$ concentrations of $\leq$30ppb were estimated from the industrial sources (in YS) to downwind regions (MY and GH located at more than 10 km west and southwest of YS, respectively) at 09:00 and 15:00 LST due to the dilution predominated by the strong easterly winds ($\geq$5m $s^{-1}$). On the other hand, there were no significant $SO_2$ concentrations ($\leq$6ppb) in US and BS. For the CHEM_LV case, $SO_2$ concentrations in the source regions of YS were considerably higher than those of the other areas (MY, GH, US, and BS) regardless of time. In the early morning (09:00 LST), significantly high $SO_2$ concentrations (156ppb) were prevalent from both the source and the surrounding regions due to both very weak winds ($\leq$1.3m $s^{-1}$) and low mixing heights (<130m at 09:00 LST). This might be because of the convergence of air masses under the LV condition, indicating the low VCs (up to 9 times lower than those of the HV condition) in the morning. Although the northerly winds (from YS to BS) were dominant in this case, the $SO_2$ contributions of the source regions in YS to BS in the afternoon (15:00 LST) were relatively weak due in part to the increased dilution in comparison with the morning.

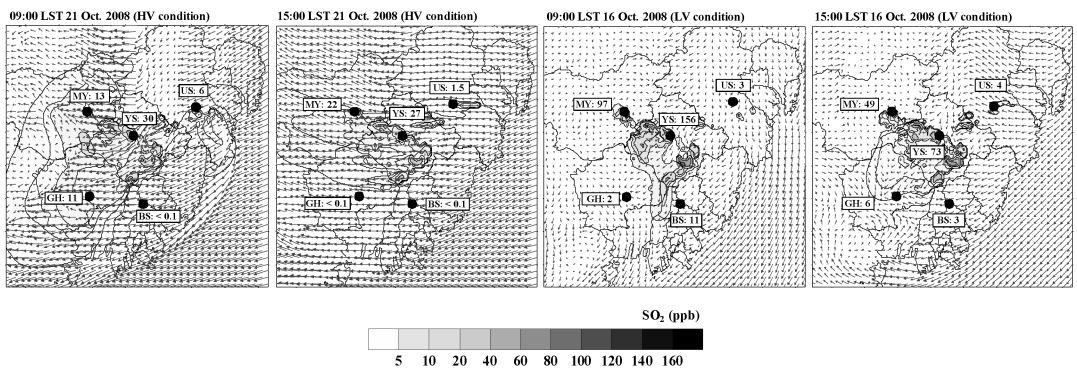


Fig. 1. Horizontal distributions of the simulated wind vectors (m $s^{-1}$) and $SO_2$ concentrations (ppb) at 09:00 and 15:00 LST for the HV and LV conditions, respectively. The values within the rectangles indicate simulated $SO_2$ concentrations in the five regions (including the target industrial source regions in YS).


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