Background

Sulfur dioxide (SO$_2$) plays a significant role in the atmosphere. It is oxidized in the atmosphere, leading to aerosol formation and acid deposition. Sulfate aerosols have highly uncertain effect on climate, are deleterious to human health, and degrade visibility. The uncertainties of SO$_2$ emissions are outstanding questions.

Objectives

- Use OMI SO$_2$ observations to constrain SO$_2$ emissions through GEOS-Chem adjoint model

Data Descriptions

- We use the OMI Level 3 best pixel column SO$_2$ at 0.25° x 0.25° resolution over China. These observations are averaged in 2.0° x 2.5° grid boxes at every data assimilation time slot (1 hour) as superobservations. Observation errors for the superobservations are considered as 1.2 D.U. over the square root of the number of pixels averaged.
- The prior anthropogenic SO$_2$ emissions are scaled from Streets-2001 inventory (Streets et al., 2003) before 2006, and are INTEX-B inventory (Zhang et al., 2009) for 2006 and later years

Observation Operator

We developed OMI SO$_2$ observation operator and validate it through finite difference method. Sensitivities calculated using the adjoint model are compared with sensitivities using centered finite differences (figure 1). All points lie along or near the 1:1 line, demonstrating the correctness and accuracy of OMI SO$_2$ observation operator.

Inversion Results

Figure 2 shows prior model simulation of column SO$_2$ are larger than OMI observations in most grid boxes. After inversion, the differences decrease and anthropogenic SO$_2$ emissions decrease in Sichuan Basin, South China and most grid boxes of North China.

Validation

| Optimized SO$_2$ emission scale factors are applied to corresponding month of the next year |

Table 1: Design of validation

<table>
<thead>
<tr>
<th>Inversion Month</th>
<th>Applying Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>April 2005</td>
</tr>
<tr>
<td>2</td>
<td>January 2006</td>
</tr>
<tr>
<td>3</td>
<td>April 2008</td>
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</table>

When the optimized SO$_2$ emissions scale factors of corresponding month of last year are applied, the relative bias and de-biased RMSE of model simulation of column SO$_2$ with respect to OMI SO$_2$ observations decreases significantly in the three case. Correlation coefficient increases in case 2 and 3, but decreases in case 1.

Outlook

The use of OMI SO$_2$ as constraints for the inversion of SO$_2$ emissions over China shows that posterior SO$_2$ emission scale factors can be applied to corresponding month of next year. Based on the promising results, we plan to assimilate OMI SO$_2$ and OMI NO$_2$ simultaneously, compare model simulations of AOD with MODIS AOD. Then we shall use OMI SO$_2$, OMI NO$_2$, and MODIS AOD as constraints to inverse SO$_2$, NO$_2$, and NH$_3$ emissions.

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References
