Atmos. Chem. Phys. Discuss., 8, S5452–S5458, 2008
www.atmos-chem-phys-discuss.net/8/S5452/2008/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "1-D air-snowpack modeling of atmospheric nitrous acid at South Pole during ANTCI 2003" *by* Wei Liao and D. Tan

Wei Liao and D. Tan

Received and published: 1 August 2008

We would like to thank the anonymous referee's comments. We will address the comment 1, 8 and 14.

1. As a function of depth (e.g., down to 30 cm) and pH, what would be the

We use the equation (3) on page 9739 line 10 to answer this question:

We define ratio1, ratio2, ratio3, ratio4 as the following:

ratio1=Q_g/S_g

ratio2=$Q_g/(S_g + 3 * lambda/a * LWC/(1 - LWC) * C_g)$

ratio3=$(C_a * P/H * 1e12)/C_g$

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

ratio4=(3*lambda/a*LWC/(1-LWC)*C$_a$ $* P/H * 1e12)/(S_g + 3 * lambda/a * LWC/(1 - LWC) * C_g)$

Where ratio1 is the gas-phase source versus sink (HONO(g) production from NO3-photochemistry versus firn air HONO(g) photolysis). Ratio2 is gas phase source versus firn air HONO(g) chemistry sink and physical uptake. Ratio3 is HONO(g) produced from equilibrium of QLL nitrite versus firn air HONO(g) chemistry sink. Ratio4 is HONO(g) produced from equilibrium of QLL nitrite versus firn air HONO(g) chemistry sink and physical uptake. We change the pH values (5.3, 5, 4.5) as those in Table 3 on page 9752. Please see table 1 to 3 for range with respect to time and depth.

Table 1 Ratio1 to ratio 4 : pH=5

Ratio1

Day of year 351.43-351.7 355.34-356.7 359.41-362.72;

Snow surface(0.62,0.70)(0.20,0.55)(0.79,0.93);

-10 cm (0.28,0.34)(0.10,0.21)(0.39,0.48);

-20 cm (0.12,0.16)(0.05,0.09)(0.18,0.23);

-30 cm (0.04,0.06)(0.03,0.04)(0.06,0.09);

Ratio2

Snow surface (0.57,0.63)(0.18,0.48)(0.72,0.83);

-10 cm (0.21,0.26)(0.07,0.15)(0.29,0.35);

-20 cm (0.07,0.09)(0.03,0.04)(0.09,0.12);

-30 cm (0.01,0.02)(0.01,0.01)(0.02,0.02);

Ratio3

Snow surface(0.64,0.72)(0.18,0.57)(0.70,0.88);

ACPD

8, S5452–S5458, 2008

Interactive Comment

-10 cm (1.40,1.72)(0.41,1.05)(1.61,2.15);

-20 cm (2.40,3.14)(0.95,1.80)(2.87,4.00);

-30 cm (4.16,5.57)(2.56,3.98)(4.99,7.21);

Ratio4

Snow surface (0.58,0.65)(0.16,0.50)(0.63,0.78);

-10 cm (1.06,1.30)(0.31,0.74)(1.22,1.55);

-20 cm (1.30,1.70)(0.52,0.85)(1.55,1.98);

-30 cm (1.18,1.58)(0.76,0.89)(1.41,1.88);

Table 2 Ratio1 to ratio 4 : pH=4.5

Ratio1

Day of year 351.43-351.7 355.34-356.7 359.41-362.72;

Snow surface (0.26,0.31)(0.07,0.20)(0.35,0.43);

-10 cm (0.09,0.12)(0.03,0.07)(0.13,0.18);

-20 cm (0.03,0.05)(0.02,0.03)(0.05,0.07);

-30 cm (0.01,0.01)(0.01,0.01)(0.02,0.02);

Ratio2

Snow surface(0.23,0.28)(0.06,0.17)(0.32,0.39);

-10 cm (0.07,0.09)(0.02,0.05)(0.10,0.13);

-20 cm (0.02,0.03)(0.01,0.01)(0.03,0.04);

-30 cm (0.00,0.00)(0.00,0.00)(0.00,0.01);

Ratio3

ACPD

8, S5452–S5458, 2008

Snow surface(0.75,0.92)(0.18,0.58)(0.86,1.15);

-10 cm (1.31,1.74)(0.39,0.96)(1.58,2.24);

-20 cm (1.93,2.68)(0.90,1.53)(2.38,3.51);

-30 cm (3.04,4.11)(2.25,3.50)(3.63,5.43);

Ratio4

Snow surface (0.68,0.83) (0.17,0.51)(0.78,1.02);

-10 cm (0.99,1.31)(0.30,0.67)(1.19,1.61);

-20 cm (1.05,1.45)(0.49,0.72)(1.28,1.80);

-30 cm (0.86,1.17)(0.67,0.77)(1.02,1.47);

Table 3 Ratio1 to ratio 4 : pH=5.3

Day of year 351.43-351.7 355.34-356.7 359.41-362.72; Ratio1

Snow surface 0.99 1.04 0.40 1.00 1.14 1.36;

-10 cm 0.61 0.66 0.20 0.49 0.73 0.86;

-20 cm 0.36 0.41 0.12 0.24 0.46 0.53;

-30 cm 0.18 0.23 0.07 0.11 0.25 0.29;

Ratio2

Snow surface 0.90 0.94 0.36 0.88 1.04 1.23;

-10 cm 0.46 0.50 0.15 0.34 0.55 0.65;

-20 cm 0.20 0.23 0.06 0.12 0.25 0.29;

-30 cm 0.05 0.06 0.02 0.03 0.07 0.08;

Ratio3

ACPD

8, S5452–S5458, 2008

Snow surface 0.52 0.55 0.18 0.53 0.53 0.66;

-10 cm 1.54 1.68 0.43 1.24 1.65 2.02;

-20 cm 3.60 4.16 1.02 2.42 4.04 5.01;

-30 cm 8.93 11.16 2.86 5.58 10.60 13.37;

Ratio4

Snow surface 0.47 0.50 0.16 0.47 0.49 0.59;

-10 cm 1.16 1.27 0.33 0.87 1.25 1.46;

-20 cm 1.95 2.25 0.56 1.15 2.18 2.48;

-30 cm 2.54 3.16 0.83 1.29 2.99 3.31;

8. Page 9739: what is the variation of [NO3-] with depth from the surface (0 cm) to 30 cm? Would including this variation as a function of depth affect the amount of HONO (g) produced as a function of depth and pH?

We keep [NO3-] constant (line 20 on page 9739) throughout this paper. We believe the variation of [NO3-] with depth changes from location to location and different time of year. We address this question by doubling the [NO3-] to see the impact on HONO (g): if the impact is very limited, it is logical to say the variation of [NO3-] with depth is not important. We pick the pH=5.3 which is the best scenario for [NO3-] as the HONO (g) source (table 1-3). We see significant improvement for ratio1 and ratio2 but very limited effect for [HONO] vertical distribution in the snowpack (figure 1-2).

Table 4 Ratio1 to ratio4

pH=5.3 and doubling [NO3-]

Ratio1

Day of year 351.43-351.7 355.34-356.7 359.41-362.72

ACPD

8, S5452–S5458, 2008

Snow surface 1.98 2.07 0.93 2.03 2.28 2.71;

-10 cm 1.20 1.32 0.39 0.97 1.45 1.70;

-20 cm 0.70 0.82 0.22 0.46 0.91 1.05;

-30 cm 0.35 0.44 0.12 0.21 0.49 0.57;

Ratio2

Snow surface 1.80 1.88 0.85 1.79 2.07 2.46;

-10 cm 0.91 1.00 0.30 0.68 1.10 1.28;

-20 cm 0.38 0.44 0.12 0.22 0.49 0.56;

-30 cm 0.10 0.13 0.03 0.05 0.13 0.16;

Ratio3

Snow surface 0.52 0.54 0.21 0.54 0.53 0.66;

-10 cm 1.52 1.67 0.43 1.24 1.64 2.02;

-20 cm 3.51 4.11 0.97 2.33 3.95 4.96;

-30 cm 8.53 10.90 2.68 5.28 10.16 13.12;

Ratio4

Snow surface 0.47 0.49 0.19 0.47 0.49 0.58;

-10 cm 1.15 1.26 0.33 0.87 1.24 1.45;

-20 cm 1.90 2.22 0.53 1.10 2.13 2.45;

-30 cm 2.43 3.09 0.78 1.22 2.86 3.24;

Figure 1 [HONO] vertical distribution with double [NO3-] and pH=5.3

Figure 2 [HONO] vertical distribution with original [NO3-] and pH=5.3

ACPD

8, S5452–S5458, 2008

We are sorry that plots can't show here but you can email us for the pdf file.Basically, the [HONO] vertical distribution looks similar although ratio1 and ratio2 change quite a lot.

Figure 3 Comparison of snowpack surface [HONO] with doubling [NO3-] (green line) and and original [NO3-] (blue line). pH sets at 5.3. We are sorry that plots can't show here but you can email us for the pdf file.When boundary layer is high, the difference is less than 10

Based on figure 1, 2, 3, as well as the figure 7(sensitivity analysis) on page 9759 in the paper, we can see the limited effect of [NO3-] on HONO(g). We can almost ignore the effect of doubling [NO3-] if we use pH=5 as in the base case model run (figure 4).

Figure 4 Comparison of snowpack surface [HONO] with doubling [NO3-] (green line) and and original [NO3-] (blue line). pH sets at 5.0.

We are sorry that plots can't show here but you can email us for the pdf file.Almost no change throughout the modeling period.

14. The pH limit where HONO will form the nitroacidium ion is pH 3, please include. We implied this information from pKa2=2.8, which is on line 1 of page 9742.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 9731, 2008.