Supporting information

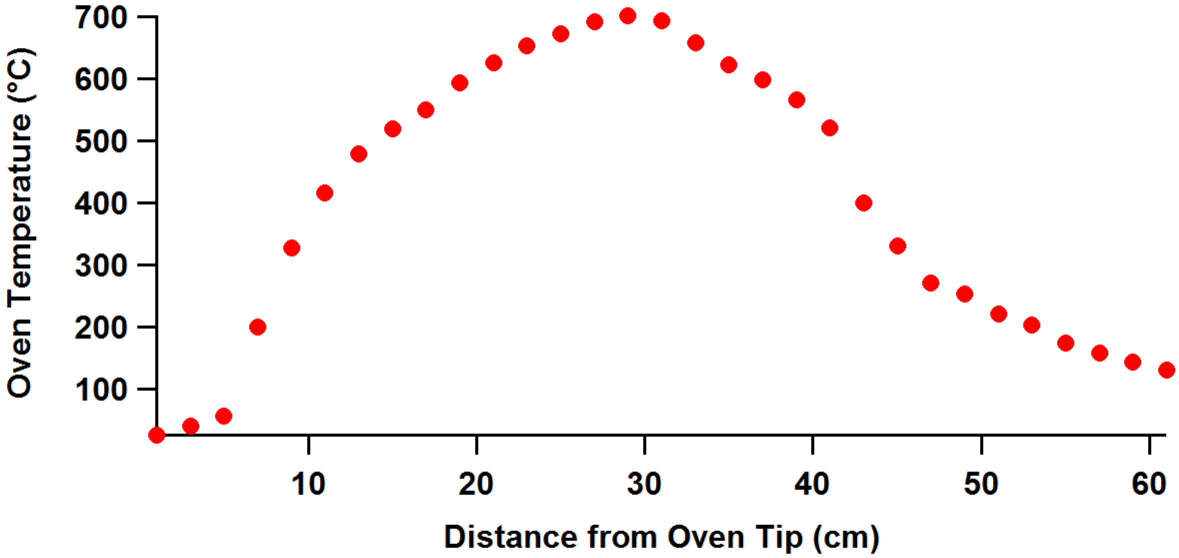

Figure S1. A sample oven temperature profile measured with a 2.0 slpm flow rate through the TD oven inlet, while the oven was set at 650 °C. Distance is measured from end of the quartz tube. The first ~5 cm are not heated, and the heated portion stretched from approximately 5 – 42 cm, with a cool down region from 42 – 63 cm.

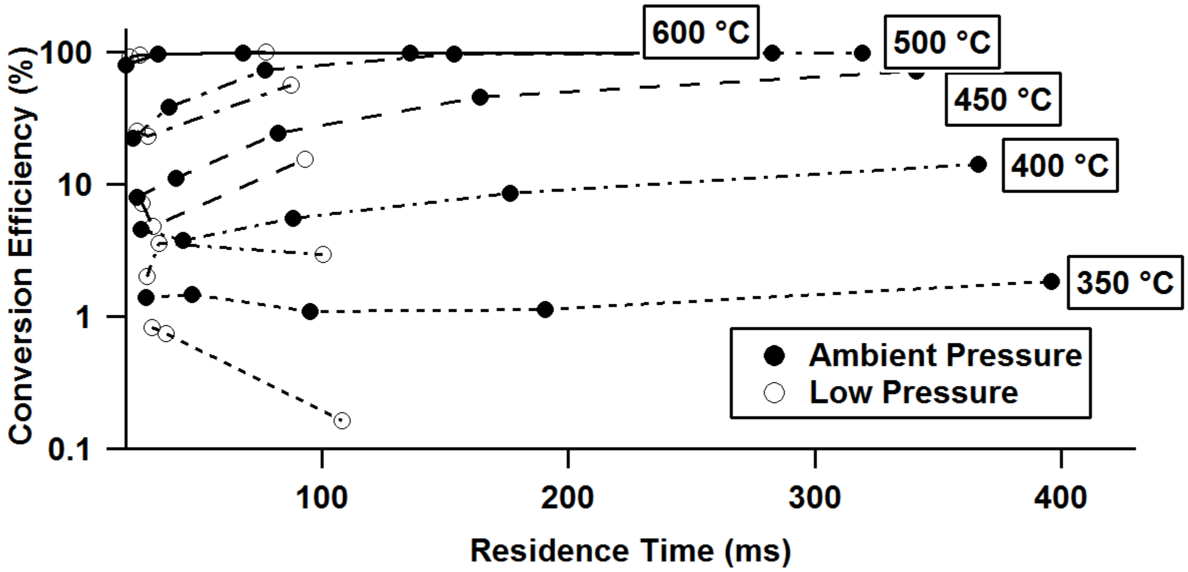

Figure S2. Log scale plot of conversion efficiency vs residence time. This plot is similar to the linear plot in Fig. 3, but is presented in log space to highlight small differences in the low conversion efficiency region.

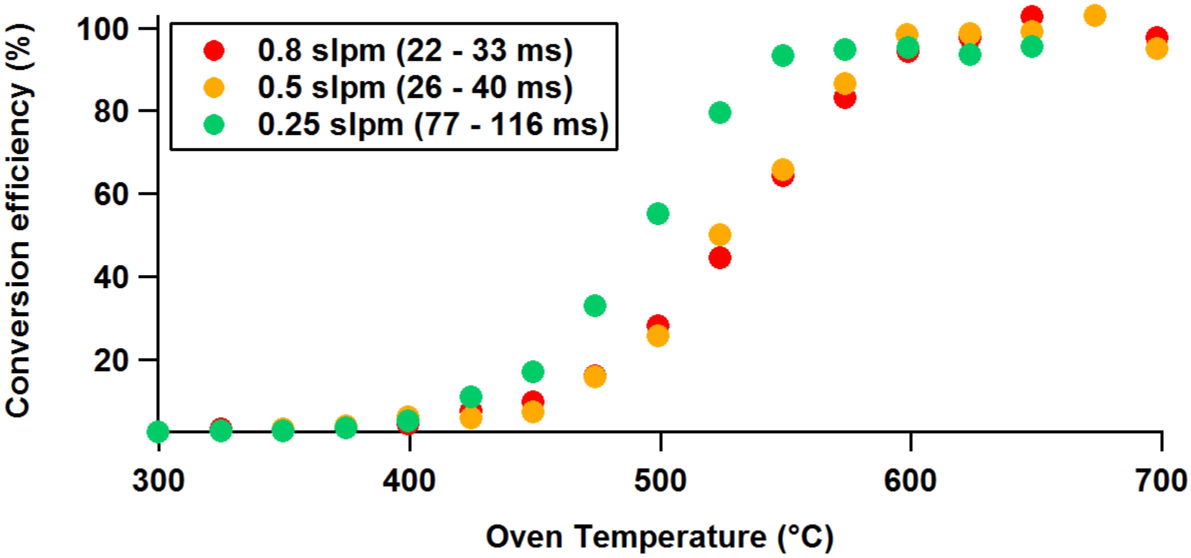

Figure S3. HNO_3 thermograms taken at low oven pressure (~250 mbar). As in Fig. 2, the onset of signal shifts to higher temperatures at faster flow rates.

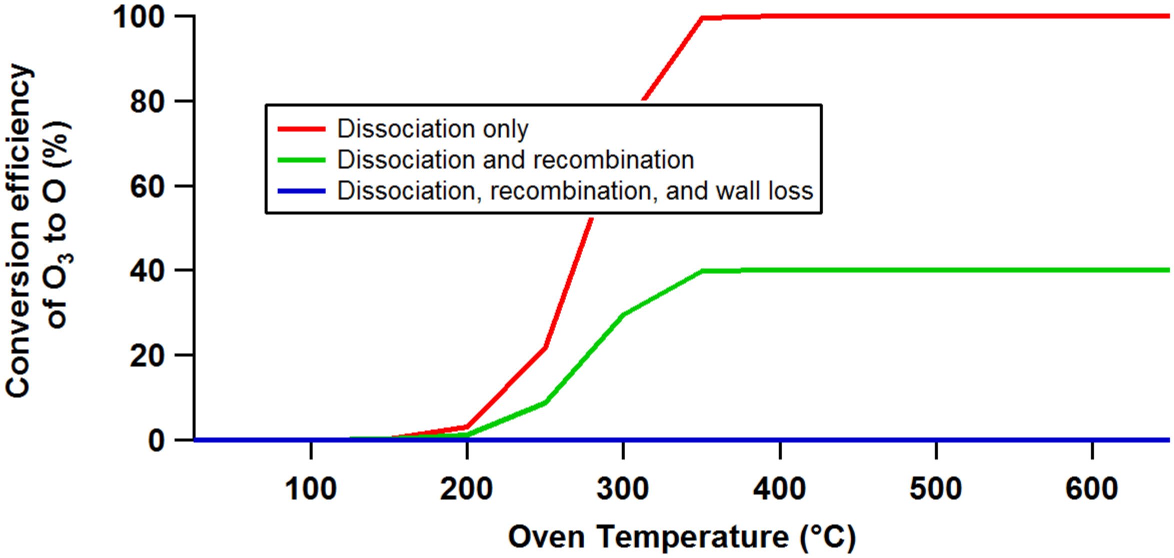

Figure S4. A simulated O_3 dissociation curve to O. These results indicate that O_3 dissociates to form O at the entire temperature range relevant for AN and HNO_3 TD ovens, but that if allowed to recombine, only ~40% will be allowed to recombine, but that nearly all O atoms could be lost to reactions with the wall.

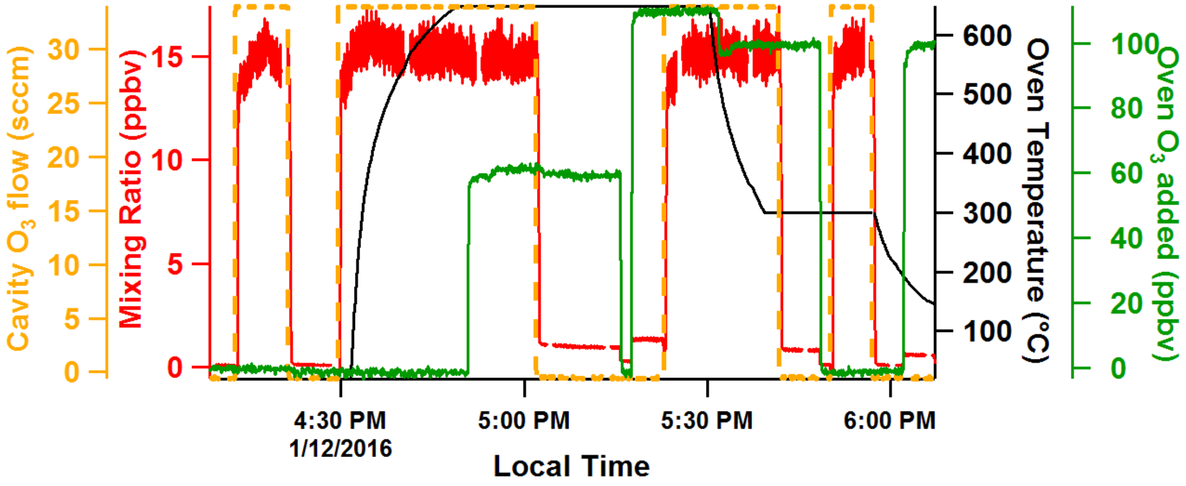

Figure S5. The measured NO_2 mixing ratios as ~15 ppbv NO in zero air is introduced to the NOy thermal dissociation inlet is shown in red. The green and yellow lines represent the addition of O_3 in two places: ppbv levels before the NO sample enters the TD inlet (green) and ppmv levels in the mixing volume just prior to entering the CRDS cavity (yellow). The mixing volume O_3 converts any NO to NO_2 prior to detection, so when this O_3 is added (such as between 4:30 and 5pm), the measured NO_2 is ~15 ppbv, as expected. When O_3 is not added to either the TD inlet or the mixing volume (such as between 4:20 and 4:30pm), no NO_2 signal is observed. However, when O_3 is added to the TD inlet, but not to the mixing volume, and the oven is at 650 °C, (such as between 5:05 and 5:15), approximately 2.25 ppbv NO_2 is observed, indicating that this NO_2 is formed by reaction of O_3 and NO in the oven. This has no effect on this TD-CRDS instrument, as any NO would be converted to NO_2 in the mixing volume region immediately following the TD oven. But techniques such as TD-LIF or TD-CRDS in which NO is not converted to NO_2 would see a ~15% conversion of ambient NO to NO_2, which must be accounted for.

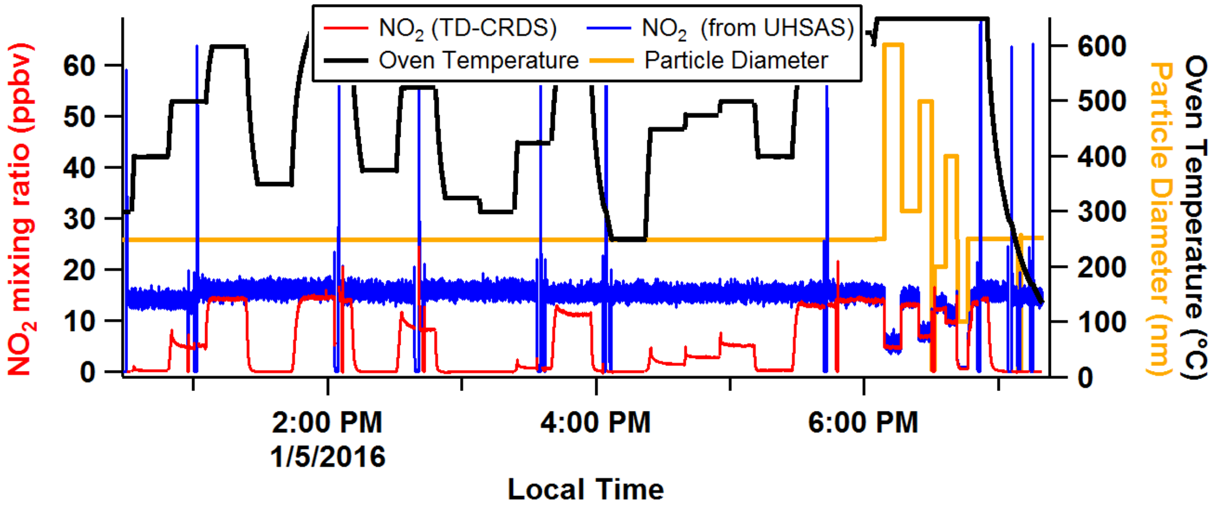

Figure S6. NO_2 signal (red) detected in the NOy channel of the TD-CRDS instrument when NH_4NO_3 aerosol is introduced to the inlets on two separate occasions. The blue trace is the expected NH_4NO_3 concentrations derived from the UHSAS measurement of the particle size distribution. The yellow indicates set DMA diameter.

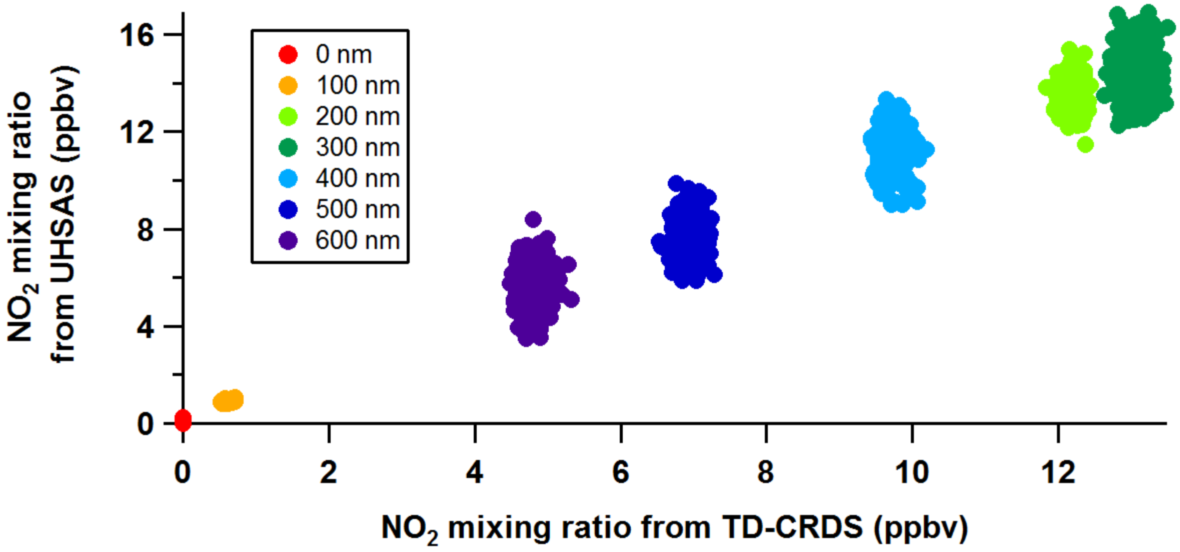

Figure S7. NO_2 mixing ratios as measured by the TD-CRDS instrument, and derived NO_2 mixing ratios from the UHSAS size distribution of NH_4NO_3 particles, colored by DMA selected size. A linear trend is shown in the scatter plot, with no dependence on particle size, emphasizing that complete conversion of the NH_4NO_3 particles is observed in the TD oven.

Table S1. Reactions used in HNO_3 box model

Rate laws are presented in table form, where the parameters listed can be inserted into the equation $k(T) = A(298/T)^n e^{-(Ea/RT)}$. For third order equations, a high pressure limit is also given. All rates taken from the JPL (http://jpldataeval.jpl.nasa.gov/), IUPAC (http://iupac.pole-ether.fr/), or NIST (http://kinetics.nist.gov/kinetics/index.jsp) databases. For reactions from the NIST database, the individual study is referenced.

Reaction	**Rate Law**						**Reference**
	A_0	n_0	Ea/R_0	A_∞	n_∞	Ea/R_∞	
$HNO_3 \rightarrow NO_2 + OH$	1.83e-4	-1.98	24054	1.26e-15	0	24054	NIST 1974GLA
$NO_3 \rightarrow NO_2 + O$	*See main text*						
$NO_3 + NO_2 \rightarrow N_2O_5$	2.0e-30	-4.4	0	1.4e-12	-0.7	0	JPL
$NO_2 + O \rightarrow NO_3$	2.50e-31	-1.8	0	2.2e-11	-0.7	0	JPL
$NO_2 + OH \rightarrow HNO_3$	1.80e-30	-3	0	2.80e-11	0	0	JPL
$NO_2 + HO_2 \rightarrow HO_2NO_2$	2.00e-31	-3.4	0	2.90e-12	-1.1	0	JPL
$NO + O \rightarrow NO_2$	9.00e-32	-1.5	0	3.00e-11	0	0	JPL
$NO + OH \rightarrow HONO$	7.00e-31	-2.6	0	3.60e-11	-0.1	0	JPL
$NO + H \rightarrow HNO$	1.22e-31	-1.17	211.6	N/A	N/A	N/A	JPL
$O_3 \rightarrow O + O_2$	7.16e-10	0	11200	N/A	N/A	N/A	NIST 1979HEI
$O_2 + H \rightarrow HO_2$	4.40e-32	-1.3	0	7.50e-11	0.2	0	JPL
$O + H \rightarrow OH$	4.36e-32	-1	0	N/A	N/A	N/A	NIST 1986TSA
$2OH \rightarrow H_2O_2$	6.90e-31	-1	0	2.60e-11	0	0	JPL
$OH + H \rightarrow H_2O$	4.38e-30	-2	0	N/A	N/A	N/A	NIST 1992BAU
$HO_2 + HO_2 \rightarrow H_2O_2 + O_2$	3.00e-13	0	-460				JPL
$N_2O_3 \rightarrow NO + NO_2$	1.90e-7	-8.7	4800	4.7e15	0.4	4880	IUPAC
$HO_2NO_2 \rightarrow HO_2 + NO_2$	4.10e-5	0	10650	4.8e15	0	11170	IUPAC
$HONO \rightarrow OH + NO$	1.98e-3	-3.8	25257	1.09e16	-1.23	25016	NIST 1991TSA
$HNO \rightarrow NO + H$	5.48e-7	-1.24	25257	N/A	N/A	N/A	NIST 1991TSA
$H_2O_2 \rightarrow 2OH$	2.03e-3	-4.86	26820	N/A	N/A	N/A	NIST 1986TSA
$N_2O_5 \rightarrow NO_2 + NO_3$	1.30e-3	-3.5	11000	9.7e14	0.1	11080	IUPAC
$HNO_3 + OH \rightarrow H_2O + NO_3$	6.50e-34	0	-1335	2.70e-17	0	-2199	JPL**
$2NO_3 \rightarrow 2NO_2 + O_2$	8.5e-13	0	2450				JPL
$NO_3 + NO \rightarrow 2NO_2$	1.79e-11	0	-109.45				NIST 1992ATK
$NO_3 + O \rightarrow O_2 + NO_2$	1.00e-17	0	0				JPL
$NO_3 + OH \rightarrow HO_2 + NO_2$	2.2e-11	0	0				JPL
$NO_3 + HO_2 \rightarrow O_2 + HNO_3$	3.5e-12	0	0				JPL
$NO_3 + H \rightarrow NO_2 + OH$	9.4e-11	0	0				NIST 1992BEC
$NO_2 + O_3 \rightarrow NO_3 + O_2$	1.2e-13	0	2450				JPL
$NO_2 + O \rightarrow NO + O_2$	5.10e-12	0	-210				JPL
$NO_2 + HNO \rightarrow HONO + NO$	1e-12	0	1000				NIST 1991TSA
$NO_2 + H \rightarrow NO + OH$	4.00e-10	0	340				JPL
$NO + O_3 \rightarrow NO_2 + O_2$	3.00e-12	0	1500				JPL
$NO + HO_2 \rightarrow NO_2 + OH$	3.30e-12	0	-270				JPL
$O_3 + O \rightarrow 2O_2$	8.00e-12	0	2060				JPL
$O_3 + OH \rightarrow HO_2 + O_2$	1.70e-12	0	940				JPL
$O_3 + HNO \rightarrow HONO + O_2$	2.56e-15	3.59	-396.9				NIST 2007XU
$O_3 + H \rightarrow O_2 + OH$	1.40e-10	0	470.26				NIST 1997DEM
$O_2 + H \rightarrow OH + O$	1.22e-11	0.96	6157.9				NIST 2012TUR

$O + OH \rightarrow O_2 + H$	1.80e-11	0	-180	2.18e-11			JPL
$O + HO_2 \rightarrow OH + O_2$	3.00e-11	0	-200				JPL
$O + N_2O_3 \rightarrow$ Products	4.30e-13	0	0				NIST 1987GEE
$O + HO_2NO_2 \rightarrow$ Products	7.8e-11	0	3400				JPL
$O + HONO \rightarrow OH + NO_2$	2.01e-11	0	3000				NIST 1991TSA
$O + HNO \rightarrow OH + NO$	6.00e-11	0	0				NIST 1991TSA
$O + H_2O_2 \rightarrow HO_2 + OH$	1.40e-12	0	2000				JPL
$2OH \rightarrow H_2O + O$	1.80e-12	0	0				JPL
$OH + HO_2 \rightarrow H_2O + O_2$	4.80e-11	0	-250				JPL
$OH + HO_2NO_2 \rightarrow H_2O_2 + NO_3$	1.30e-12	0	-380				JPL
$OH + HO_2NO_2 \rightarrow HO_2 + HNO_3$	1.30e-12	0	-380				JPL
$OH + HONO \rightarrow H_2O + NO_2$	1.80e-11	0	390				JPL
$OH + HNO \rightarrow H_2O + NO$	8.00e-11	0	500				NIST 1991TSA
$OH + H_2O_2 \rightarrow HO_2 + H_2O$	2.90e-12	0	160				IUPAC
$HO_2 + H_2O_2 \rightarrow OH + H_2O + O_2$	1.00e-13	0	0				NIST 1974VAR
$HO_2 + H \rightarrow H_2O + O$	5.00e-11	0	865.95				NIST 1992BAU
$HO_2 + H \rightarrow 2OH$	2.81e-10	0	440.19				NIST 1992BAU
$HO_2 + H \rightarrow O_2 + H_2$	7.11e-11	0	709.6				NIST 1992BAU
$HO_2NO_2 + H \rightarrow$ Products	2.46e-14	0	0				NIST 1981TRE
$HONO + H \rightarrow H_2O + NO$	6.39e-13	1.89	1940				NIST 1997HSU
$HONO + H \rightarrow OH + HNO$	1.26e-11	0.86	2500				NIST 1997HSU
$HNO + H \rightarrow H_2 + NO$	3.01e-11	0	500				NIST 1991TSA
$H_2O_2 + H \rightarrow OH + H_2O$	1.69e-11	0	1800				NIST 1992BAU
$H_2O_2 + H \rightarrow H_2 + HO_2$	2.81e-12	0	1889.5				NIST 1992BAU
$OH \rightarrow$ Wall	46 s^{-1}						**See main text
$O \rightarrow$ Wall	70 s^{-1}						**See main text
$C_3H_8 + O \rightarrow C_3H_7 + OH$	1.37e-12	2.68	1870.2				NIST 1988TSA
$C_3H_8 + H \rightarrow C_3H_7 + H_2$	4.23e-12	2.54	3400				NIST 1988TSA
$C_3H_8 + NO_3 \rightarrow C_3H_7 + HNO_3$	4.17e-12	0	3260.6				NIST 2002BRA
$C_3H_8 + NO_2 \rightarrow C_3H_7 + HONO$	4.00e-13	0	11400				NIST 1976TIT
$C_3H_8 + O_3 \rightarrow$ Products	2.74e-13	0	7270				NIST 1963MOR
$C_3H_8 + OH \rightarrow C_3H_7 + H_2O$	1.44e-12	1	130				NIST 1985WAL
$C_3H_7 + O \rightarrow$ Products	1.37e-12	2.68	1870				NIST 1988TSA
$CO + O \rightarrow CO_2$	1.70e-33	0	1509	1e-14	0	1629	NIST 1986TSA

Reactions used in N_2O_5 box model

Reaction	**Rate Law**						**Reference**
	A_0	n_0	Ea/R_0	A_∞	n_∞	Ea/R_∞	
$NO_3 + NO_2 \rightarrow N_2O_5$	2.0e-30	-4.4	0	1.4e-12	-0.7	0	JPL
$NO_2 + O \rightarrow NO_3$	2.50e-31	-1.8	0	2.2e-11	-0.7	0	JPL
$NO + O \rightarrow NO_2$	9.00e-32	-1.5	0	3.00e-11	0	0	JPL
$O_2 + O \rightarrow O_3$	6.00e-34	-2.4	0	0	0	0	JPL
$O + O \rightarrow O_2$	5.21e-35	0	-900				NIST 1986TSA
$N_2O_5 \rightarrow NO_2 + NO_3$	1.30e-3	-3.5	11000	9.7e14	0.1	11080	IUPAC
$NO_3 + NO \rightarrow 2NO_2$	1.79e-11	0	-109.45				NIST 1992ATK
$NO_3 + O \rightarrow O_2 + NO_2$	1.00e-17	0	0				JPL
$NO_2 + O \rightarrow NO + O_2$	5.10e-12	0	-210				JPL

$NO_2 + O_3 \rightarrow NO_3 + O_2$	1.2e-13	0	2450				JPL
$NO + O_3 \rightarrow NO_2 + O_2$	3.00e-12	0	1500				JPL
$O_3 \rightarrow O + O_2$	7.16e-10	0	11200	N/A	N/A	N/A	NIST 1979HEI
$O \rightarrow$ Walls	70 s^{-1}						*see main text*
$NO_3 \rightarrow NO_2 + O$	*see main text*						

Reactions used in NH_3 box model

Reaction	**Rate Law**						**Reference**
	A_0	n_0	Ea/R_0	A_∞	n_∞	Ea/R_∞	
$HNO \rightarrow NO + H$	5.48e-7	-1.24	25257	N/A	N/A	N/A	NIST 1991TSA
$NH_3 + O \rightarrow NH_2 + OH$	2.87e-13	2.1	0				NIST 1991COH
$NH_3 + OH \rightarrow NH_2 + H_2O$	4.48e-13	1.8	0				NIST 1986JEF
$NH_2 + O_3 \rightarrow NH_2O + O_2$	4.9e-12	0	1000				NIST 2004ATK
$NH_2 + O \rightarrow HNO + H$	7.47e-11	0	0				NIST 1991COH
$NH_2 + O \rightarrow OH + NH$	1.16e-11	0	0				NIST 1991COH
$NH_2 + O \rightarrow NO + H_2$	8.30e-12	0	0				NIST 1991COH
$NH_2 + NH_2 \rightarrow N_2H_4$	1.96e-29	-3.9	0	N/A	N/A	N/A	NIST 1995FAG
$NH_2 + OH \rightarrow NH_2OH$	6.77e-10	-3.23	673				NIST 2009MOU
$NH_2 + OH \rightarrow NH + H_2O$	7.69e-13	1.5	-230				NIST 1991COH
$NH_2 + OH \rightarrow NH_3 + O$	4.95e-15	2.6	-870				NIST 1991COH
$NH_2 + NH \rightarrow N_2H_2 + H$	1.5e-10	-0.27	-38.4				NIST 2009KLI
$NH_2 + NH_2OH \rightarrow NH_3 + NH_2O$	1.42e-15	4	-13.03				NIST 2009KLI
$NH_2O + O_3 \rightarrow$ Products	2.01e-14	0	0				NIST 1980BUL
$NH_2O + OH \rightarrow H_2O + HNO$	1.66e-12	0	0				NIST 1992LIN
$NH_2OH \rightarrow OH + NH_2$	0.16	-5.96	33555				NIST 2009KLI
$NH + OH \rightarrow HNO + H$	3.32e-11	0	0				NIST 1991COH
$NH_2OH + NH \rightarrow NH_2 + NH_2O$	3.73e-16	4.4	786.6				NIST 2009KLI
$NO + O \rightarrow NO_2$	9.00e-32	-1.5	0	3.00e-11	0	0	JPL
$NO + O_3 \rightarrow NO_2 + O_2$	3.00e-12	0	1500				JPL
$NO_2 + O \rightarrow NO_3$	5.10e-12	0	-210				JPL
$NO_2 + O_3 \rightarrow NO_3 + O_2$	1.2e-13	0	2450				JPL
$NO_3 \rightarrow NO_2 + O$	**See main text						
$NO + H \rightarrow HNO$	1.22e-31	-1.17	211.6	N/A	N/A	N/A	JPL
$O_3 \rightarrow O + O_2$	7.16e-10	0	11200	N/A	N/A	N/A	NIST 1979HEI
$NO_3 + NO \rightarrow NO_2 + NO_2$	1.79e-11	0	-109.45				NIST 1992ATK
$NO_3 + O \rightarrow O_2 + NO_2$	1.00e-17	0	0				JPL
$NO_3 + OH \rightarrow HO_2 + NO_2$	2.2e-11	0	0				JPL
$HNO + H \rightarrow NH_2 + O$	1.05e-9	-0.3	14673				NIST 1991COH
$HNO + H \rightarrow OH + NH$	2.41e-9	-0.5	9009				NIST 1991COH
$HNO + H \rightarrow H_2 + NO$	3.01e-11	0	500				NIST 1991TSA
$O + HNO \rightarrow OH + NO$	6.00e-11	0	0				NIST 1991TSA
$OH + HNO \rightarrow H_2O + NO$	8.00e-11	0	500				NIST 1991TSA
$O \rightarrow$ Walls	~70 s^{-1}						**See main text
$OH \rightarrow$ Walls	~46 s^{-1}						**See main text