HAMMONIA

- Hamburg Model of the Neutral and Ionized Atmosphere
- General Circulation and Chemistry Model
- vertical extension: from the surface up to the thermosphere (250km)

HAMMONIA

Ionization and reaction rates:

- Ionization rates provided by AIMOS

  3-D
  time dependent
  (protons, electrons, alpha particles) **here only protons**

- above 0.001hPa: ionization rates are explicitly used for calculation of reaction rates of ionization, dissociation, and excitation of O, O_2, N, N_2

- below 0.001hPa: parametrizations from Porter et al.,1976 (J. Chem. Phys.) and Solomon et al., 1981 (Planet. Space Sci.) are used to produce:

  0.7 $N(^2D)$, 0.55 $N(^4S)$ per ion pair
  OH, H (ca 2 HO_X per ion pair)

- nudging from surface to tropopause

HAMMONIA

Reaction rates (involving NOx): from JPL15 (2006)

N + O2 → NO + O
N + NO → N2 + O

NO + HO2 → NO2 + OH
NO + O3 → NO2 + O2

NO2 + O → NO + O2
NO2 + O3 → NO3 + O2
NO2 + N → N2O + O
NO2 + H → OH + NO

NO3 + NO → NO2 + NO2
NO3 + O → NO2 + O2
NO3 + OH → HO2 + NO2
NO3 + HO2 → OH + NO2 + O2
NO3 + NO3 → NO2 + NO2 + O2

HAMMONIA

Reaction rates (involving NOx):

$HNO_3 + OH \rightarrow NO_3 + H_2O$

$NO + O + M \rightarrow NO_2 + M$

$NO_2 + O + M \rightarrow NO_3 + M$

$NO_2 + NO_3 + M \rightarrow N_2O_5 + M$

$NO_2 + OH + M \rightarrow HNO_3 + M$

$NO_2 + HO_2 + M \rightarrow HO_2NO_2 + M$

} JPL15 (2006)

$NO + h\nu \rightarrow N + O$ Minschwaner and Siskind, 1998, JGR

$HNO_3 + h\nu \rightarrow NO_2 + OH$

$N(^2D) + O_2 \rightarrow NO + O$	rate coefficient	2.95e-12
$N(^2D) + O_2 \rightarrow NO + O(^1D)$	rate coefficient	2.95e-12
$N(^2D) + O \rightarrow N + O$	rate coefficient	4.5e-13
$N(^2D) + NO \rightarrow N_2 + O$	rate coefficient	7.e-11

HAMMONIA

Reaction rates (involving HOx): from JPL15 (2006)

$$H + O_3 \rightarrow OH + O_2$$
$$H + HO_2 \rightarrow OH + OH$$
$$H + HO_2 \rightarrow H_2 + O_2$$
$$H + HO_2 \rightarrow H_2O + O$$

$$OH + O \rightarrow H + O_2$$
$$OH + O_3 \rightarrow HO_2 + O_2$$
$$OH + HO_2 \rightarrow H_2O + O_2$$
$$OH + OH \rightarrow H_2O + O$$
$$OH + H_2 \rightarrow H_2O + H$$
$$OH + H_2O_2 \rightarrow H_2O + HO_2$$

$$HO_2 + O \rightarrow OH + O_2$$
$$HO_2 + O_3 \rightarrow OH + 2 \cdot O_2$$
$$HO_2 + HO_2 \rightarrow H_2O_2 + O_2$$

HAMMONIA

Reaction rates (involving HOx): from JPL15 (2006)

$$H_2O_2 + O \rightarrow OH + HO_2$$

$$H + O_2 + M \rightarrow HO_2 + M$$

$$OH + OH + M \rightarrow H_2O_2 + M$$

$$H + H + M \rightarrow H_2 + M$$ (taken from Roble 1995)

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$$N + NO \rightarrow N_2 + O$$

$$NO + HO_2 \rightarrow NO_2 + OH$$
$$NO + O_3 \rightarrow NO_2 + O_2$$

$$NO_2 + O \rightarrow NO + O_2$$
$$NO_2 + O_3 \rightarrow NO_3 + O_2$$
$$NO_2 + N \rightarrow N_2O + O$$
$$NO_2 + H \rightarrow OH + NO$$

$$NO_3 + NO \rightarrow NO_2 + NO_2$$
$$NO_3 + O \rightarrow NO_2 + O_2$$
$$NO_3 + OH \rightarrow HO_2 + NO_2$$
$$NO_3 + HO_2 \rightarrow OH + NO_2 + O_2$$
$$NO_3 + NO_3 \rightarrow NO_2 + NO_2 + O_2$$

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