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Production of H, OH, HNO_2, and HNO_3 by particle precipitation

P. T. Verronen
Finnish Meteorological Institute, Earth Observation, Helsinki, Finland

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The CHAMOS Team

P. T. Verronen, E. Kyrölä, J. Tamminen, S.-M. Salmi

Finnish Meteorological Institute, Earth Observation, Helsinki, Finland

E. Turunen

EISCAT Scientific Association, Kiruna, Sweden

Th. Ulich, C.-F. Enell, A. Kero, T. Raita

Sodankylä Geophysical Observatory, University of Oulu, Sodankylä, Finland

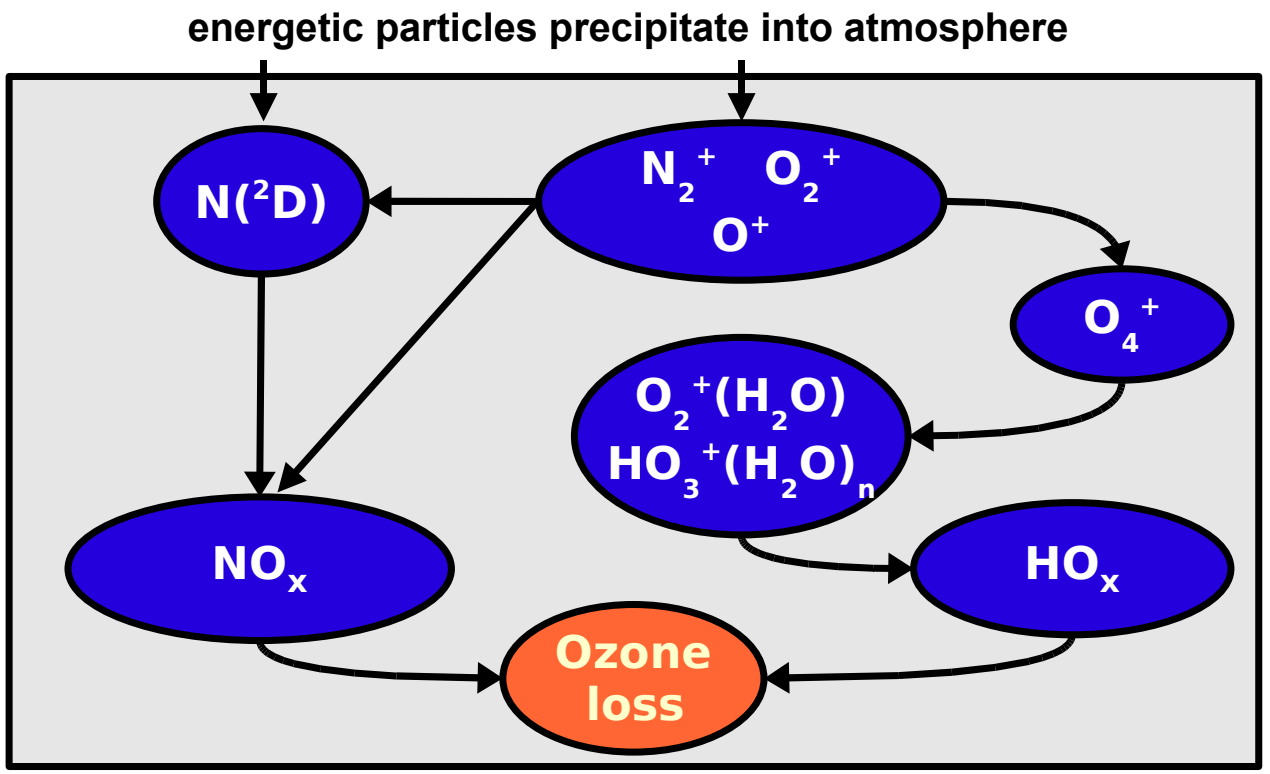
C. J. Rodger

University of Otago, Department of Physics, Dunedin, New Zealand

M. A. Clilverd, A. Seppälä

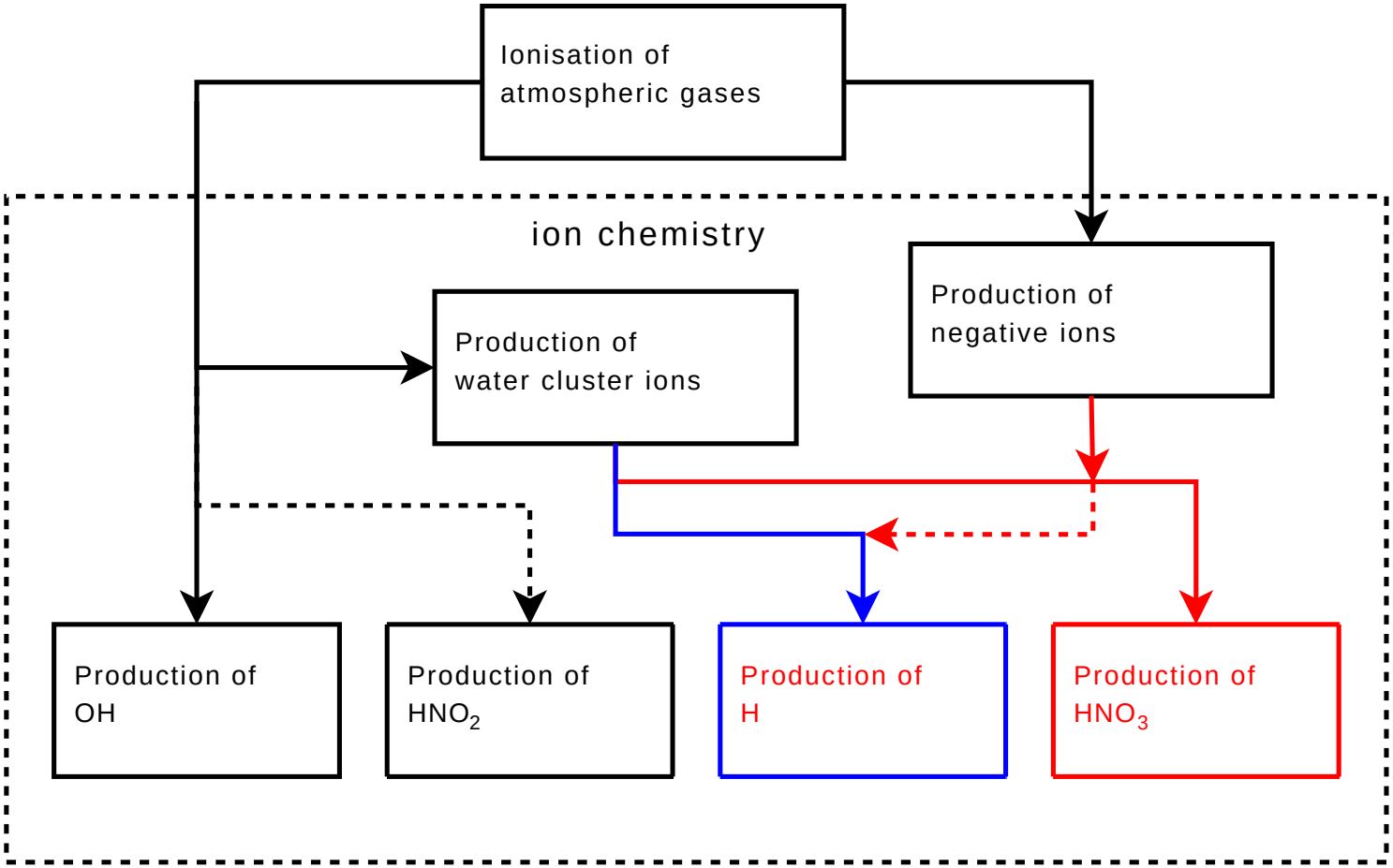
British Antarctic Survey (NERC), Physical Sciences Division, Cambridge, UK

Atmospheric effects of EPP



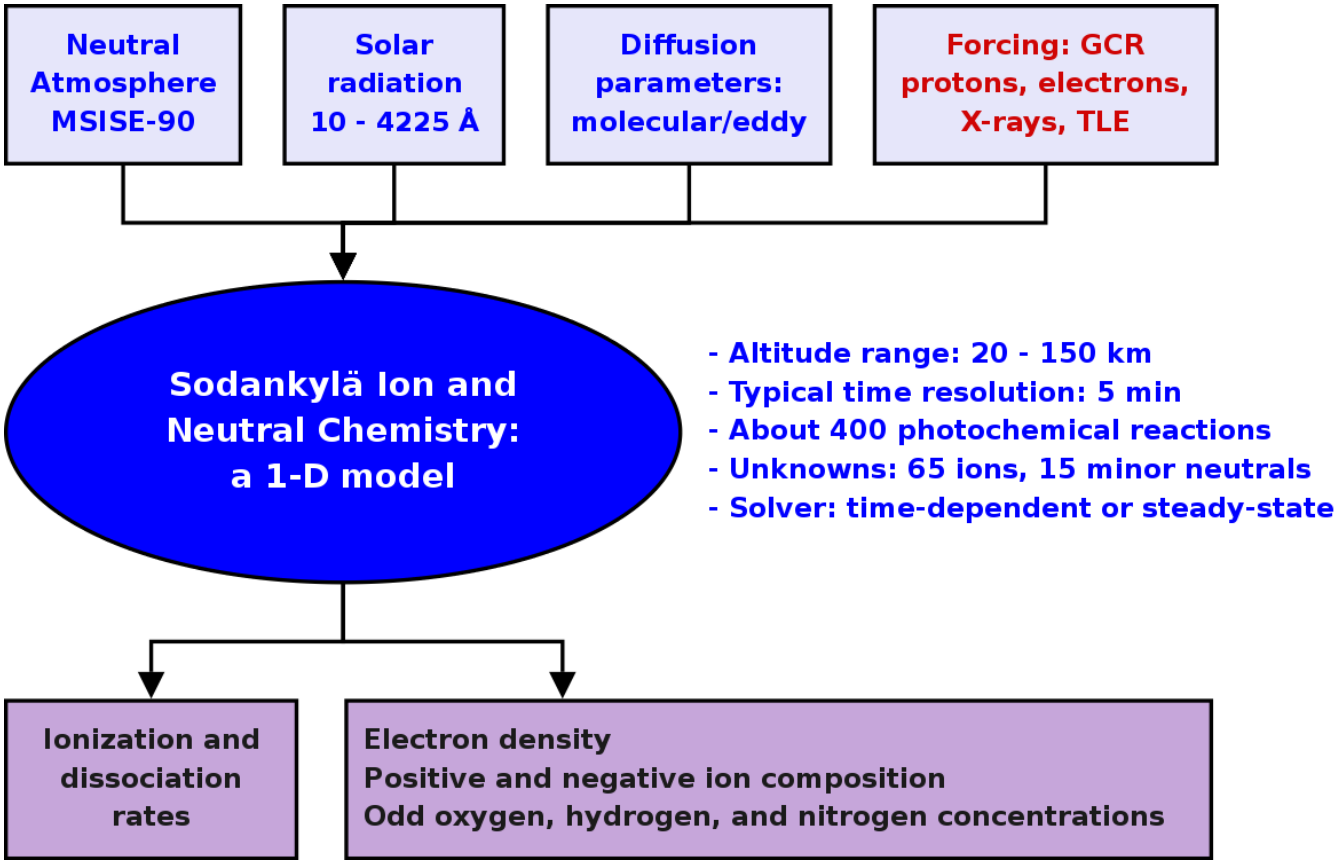
Ozone connects to temperature and dynamics

EPP: production of HO_x (and HNO_x) species



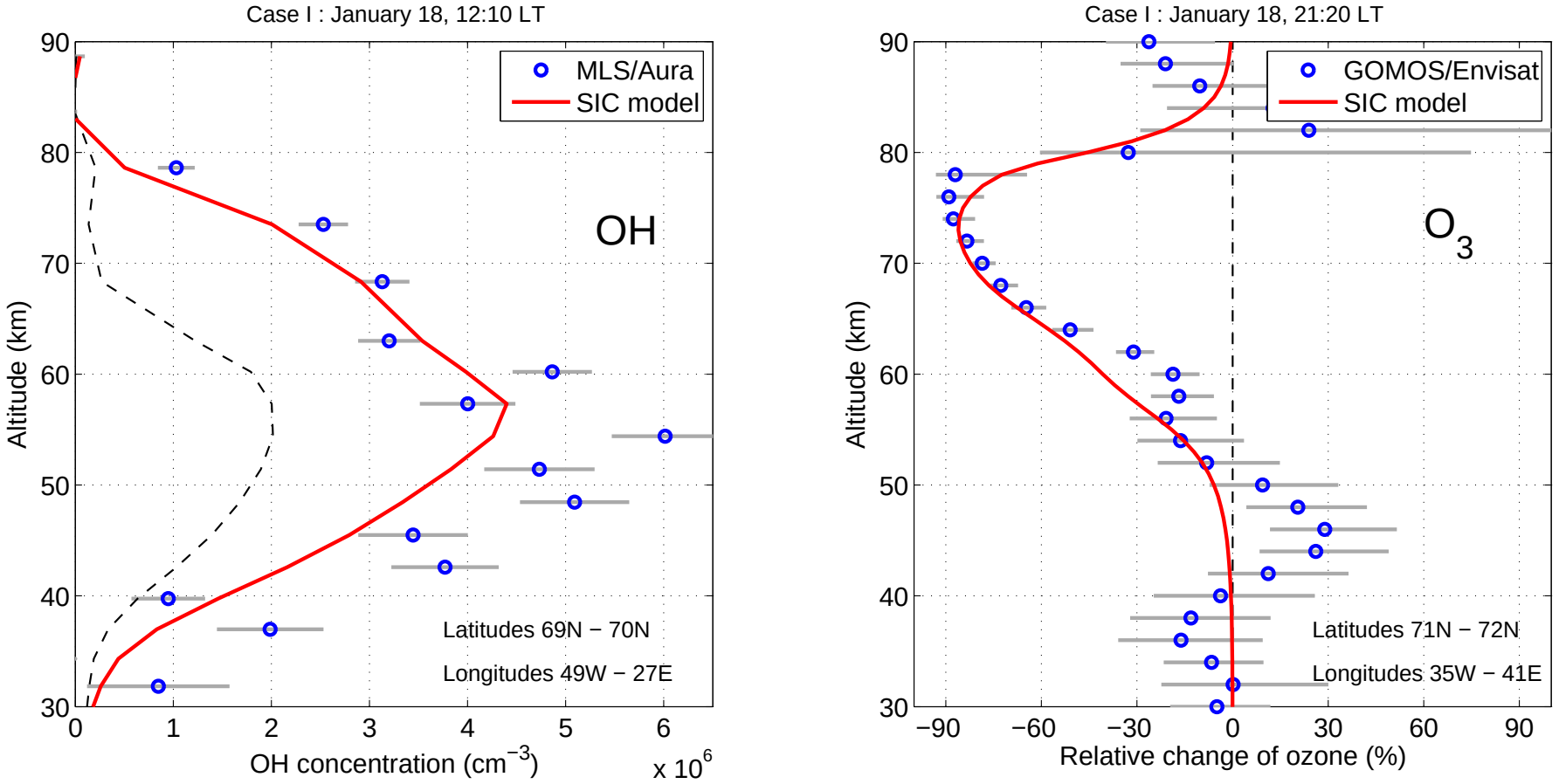
(1) H_2O dissociated $\rightarrow$ OH (2) Recombination $\rightarrow$ H released

Sodankylä Ion and Neutral Chemistry (SIC)



OH and ozone – SIC vs. satellites

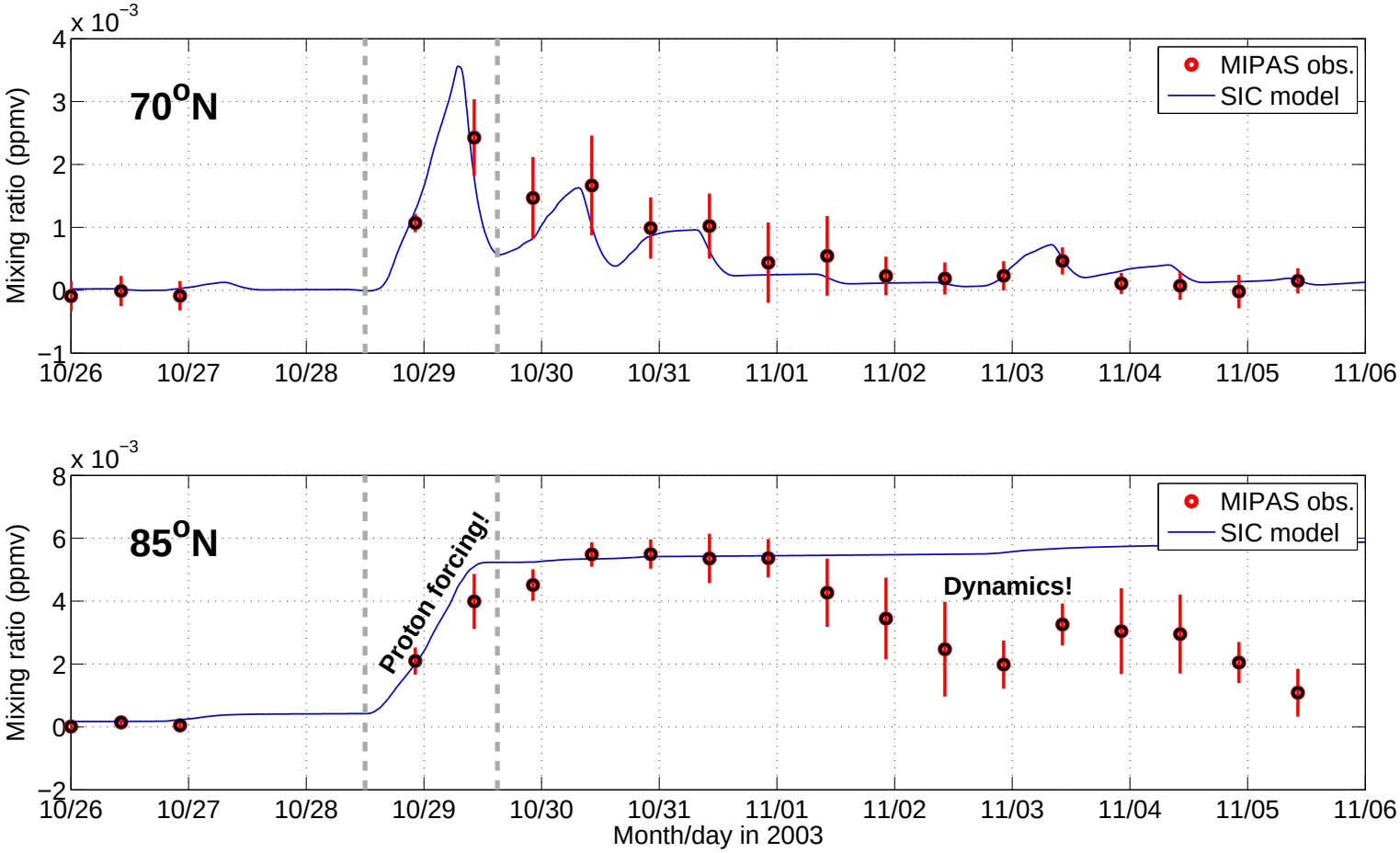
SPE of January 2005



From Verronen et al., *Geophys. Res. Lett.*, 2006

HNO_3 at 46 km – SIC vs. MIPAS/Envisat

SPE of October-November 2003



From Verronen et al., *Geophys. Res. Lett.*, 2008

New parameterization of EPP effects

Why is it needed?

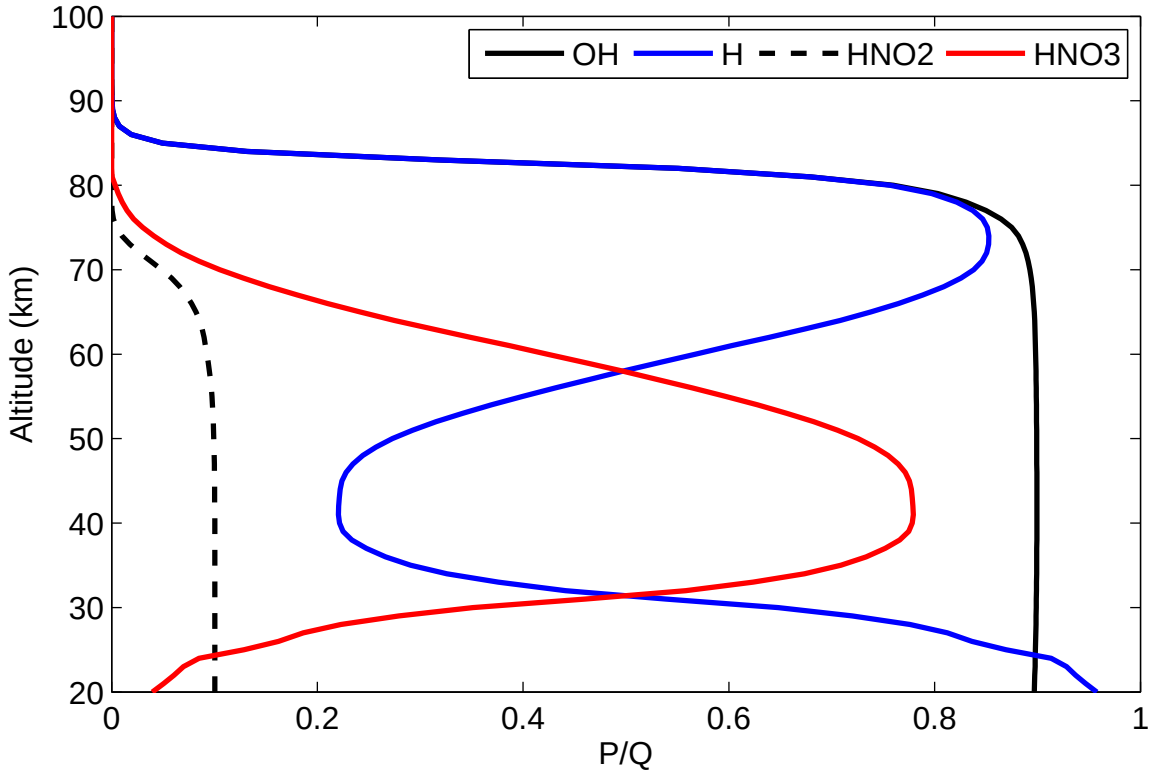
- Currently, production of HNO_3 and HNO_2 is ignored
- Balance between HO_x and HNO_3 production is important
  - Depends on solar illumination (solar zenith angle)
  - Determines if the ion chemistry effects are short-term or long-term
- Ion chemistry is computationally expensive (64 ions, hundreds of reactions)

SIC-based P/Q numbers

- P/Q numbers?
  - Chemical production rate divided by ionization rate
  - Separate number for H, OH, HNO_2, and HNO_3
  - Different set of P/Qs for different seasons of the year
- Based on an ensemble of model runs
  - Latitudes 50° – 75°
  - Ionization rates 10^0 – 10^5 $cm^{-3}s^{-1}$
- Altitude profiles of P/Qs
  - Averaged over latitudes, into 5°-wide bins of SZA

P/Q: dependence on altitude

January NH, Q = $10^3 cm^{-3} s^{-1}$, SZA = 105°

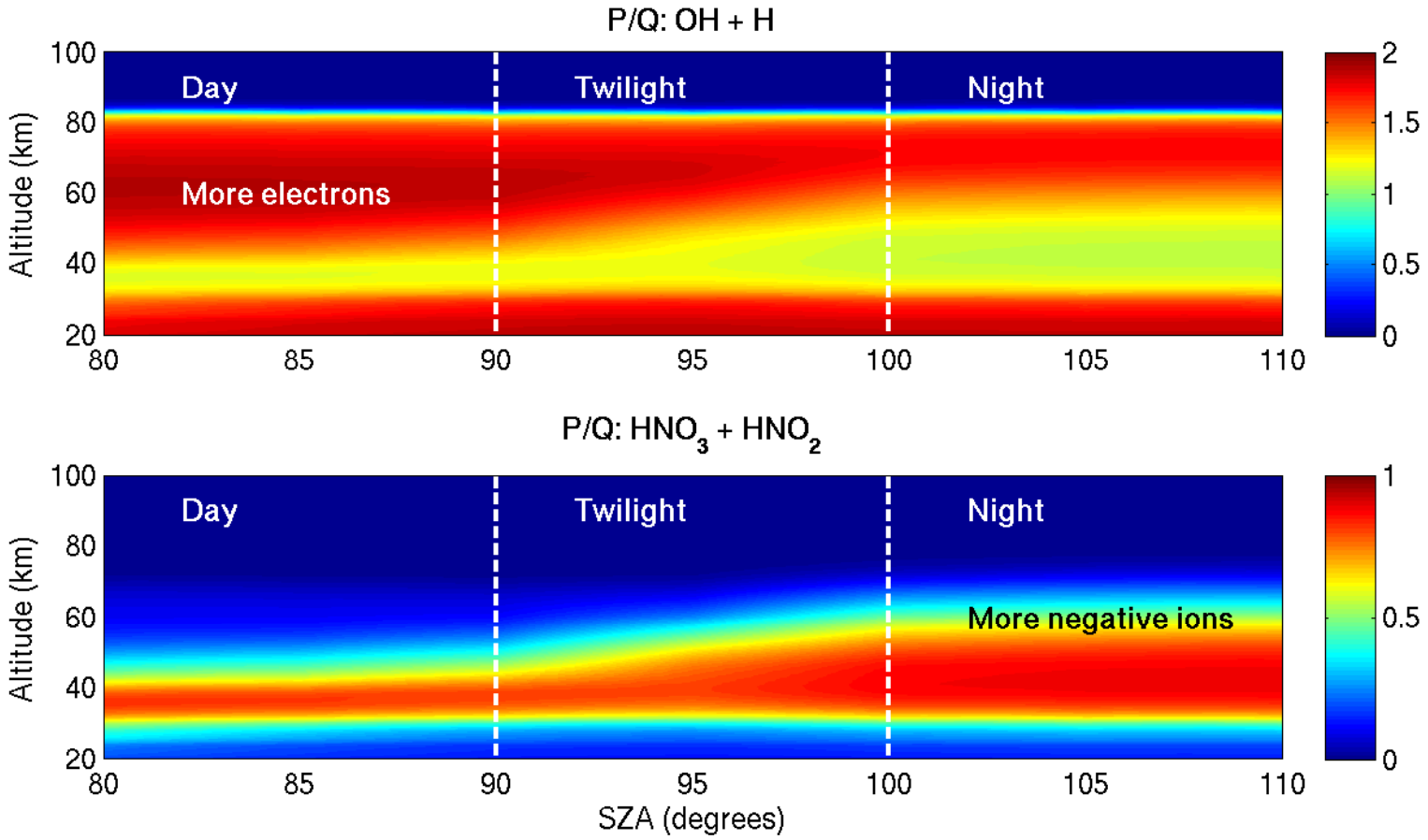


Production of OH and HNO_2 depends on the amount of H_2O

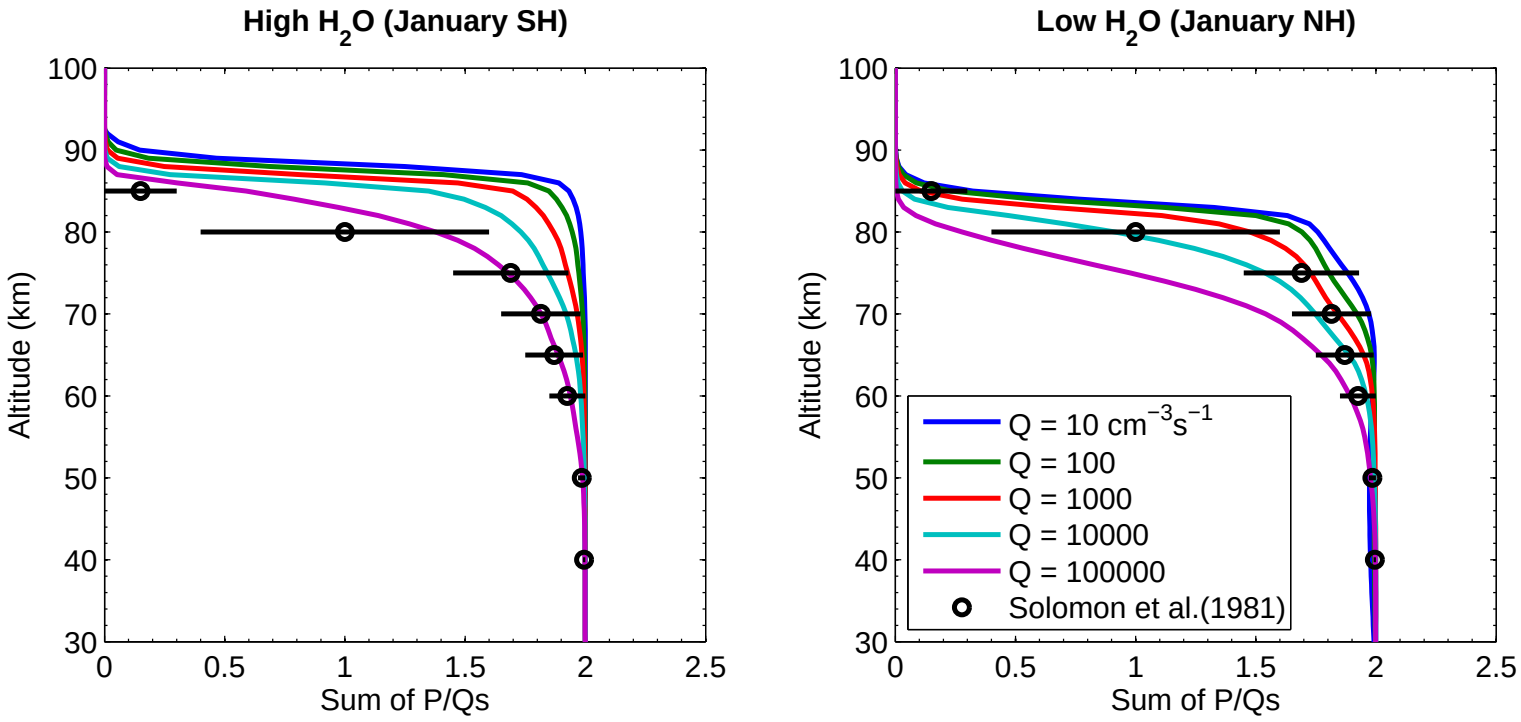
Production of HNO_3/H depends also on $[NO_3^-]/([e^-] + [X^-])$ ratio

P/Q: dependence on SZA

January NH, Q = $10^3 \mathrm{cm}^{-3}\mathrm{s}^{-1}$



P/Q: dependence on ionization rate



- Sum of P/Qs = $(P_H + P_{OH} + P_{HNO_2} + P_{HNO_3})/Q$
- Neutral composition of the atmosphere affects P/Qs

Using P/Qs in atmosphere models: tables

Table 9. P_{HNO_3}/Q for October NH.

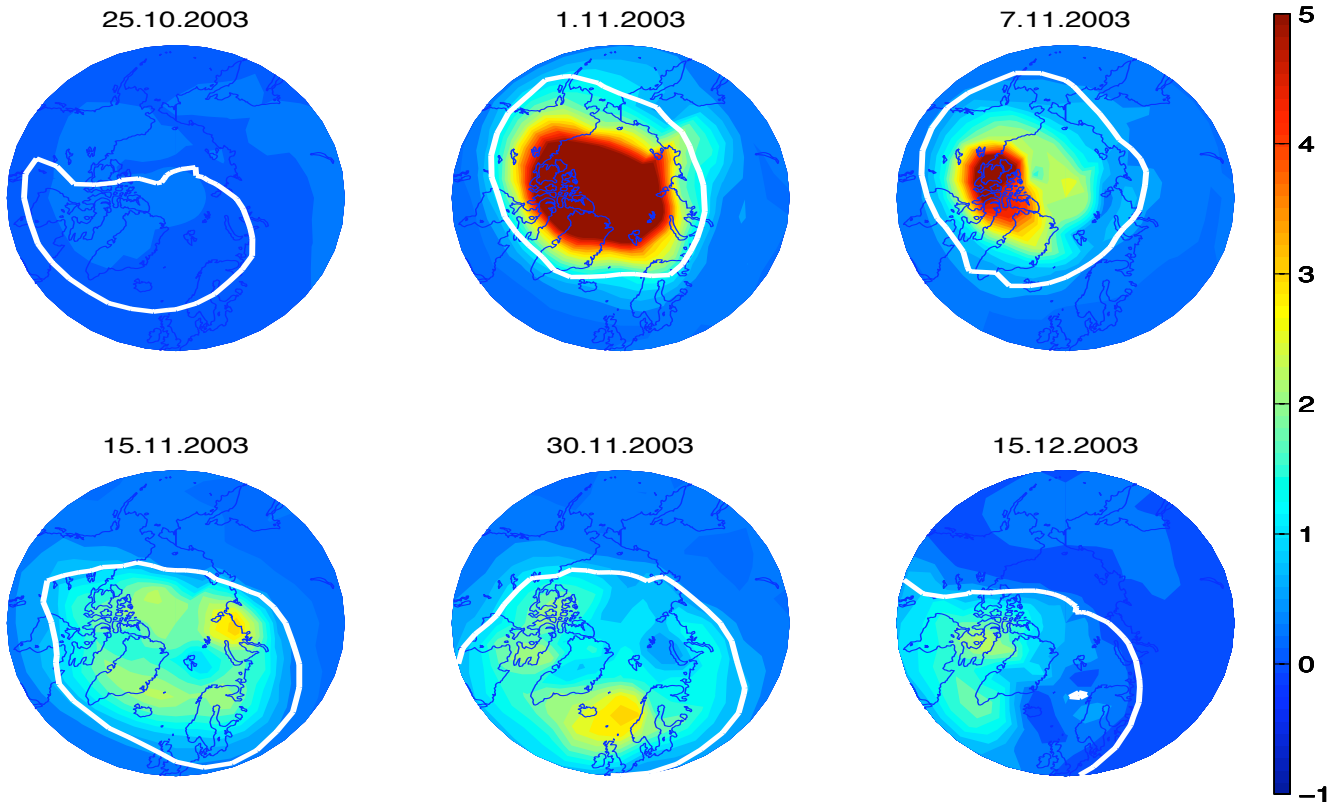
Q	10^1	10^2	10^3	10^4	10^5	10^1	10^2	10^3	10^4	10^5	10^1	10^2	10^3	10^4	10^5
km		SZA	$\leq$	90°			SZA	=	95°			SZA	$\geq$	100°	
90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.00
75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.04	0.04	0.01	0.00
70	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.19	0.13	0.12	0.07	0.03
65	0.00	0.00	0.00	0.01	0.01	0.06	0.04	0.05	0.06	0.04	0.44	0.29	0.27	0.20	0.10
60	0.00	0.00	0.02	0.05	0.06	0.19	0.15	0.17	0.21	0.16	0.68	0.51	0.44	0.41	0.27
55	0.02	0.03	0.08	0.18	0.22	0.44	0.39	0.36	0.42	0.37	0.79	0.71	0.60	0.60	0.49
50	0.09	0.14	0.22	0.36	0.46	0.61	0.62	0.56	0.58	0.62	0.77	0.79	0.72	0.73	0.72
45	0.45	0.42	0.44	0.51	0.59	0.80	0.75	0.66	0.63	0.68	0.86	0.82	0.77	0.74	0.78
40	0.85	0.78	0.64	0.55	0.57	0.90	0.83	0.69	0.59	0.62	0.94	0.88	0.77	0.69	0.72
35	0.89	0.80	0.62	0.46	0.45	0.90	0.81	0.63	0.48	0.49	0.94	0.87	0.72	0.58	0.60
30	0.79	0.65	0.41	0.25	0.24	0.80	0.66	0.43	0.27	0.27	0.85	0.73	0.51	0.34	0.35
25	0.54	0.40	0.20	0.11	0.10	0.54	0.40	0.21	0.12	0.12	0.60	0.46	0.26	0.15	0.16
20	0.33	0.25	0.13	0.06	0.05	0.32	0.25	0.12	0.06	0.06	0.35	0.26	0.13	0.07	0.07

Needed: SZA and ionization rate

Output: Production rates of H, OH, HNO_2, and HNO_3

3-D modelling with P/Q parameterization

HNO_3 (ppbv) at 45 km, Oct–Dec 2003, FinROSE CTM



For more, see the poster by Salmi et al.

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Summary

- EPP produces H, OH, HNO_2, and HNO_3 through ion chemistry
- P/Q numbers provide a simple way to include ion chemistry effects in any atmospheric model
- Sets of P/Qs have been calculated with the Sodankylä Ion and Neutral Chemistry Model (SIC), taking into account the dependence on SZA, ionization rate, and season of the year
- Validation of the new P/Q numbers is needed