Response of Ion and Neutral Composition of Lower Ionosphere During Bursts of Auroral Electrons

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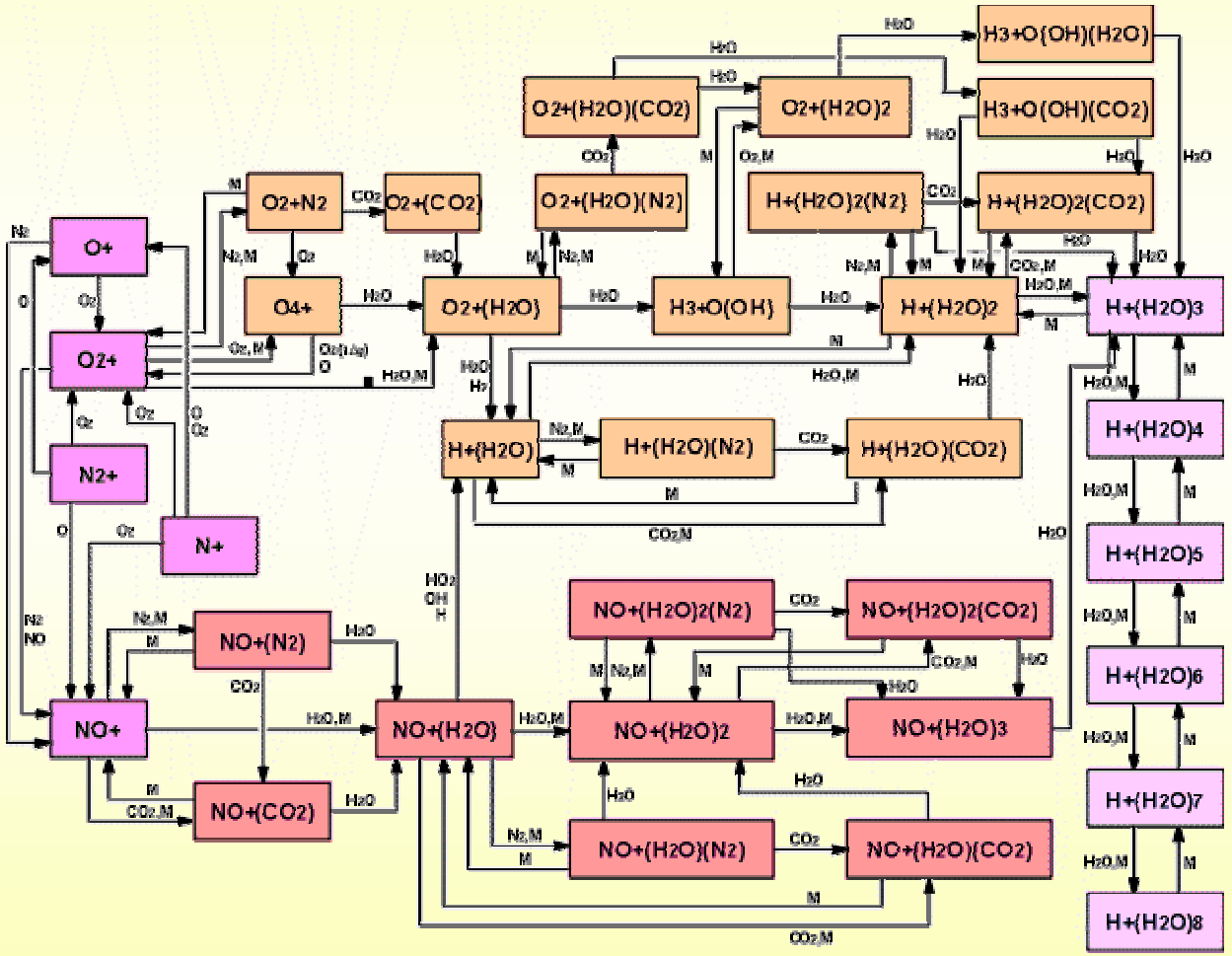
Sodankylä Ion Chemistry: SIC

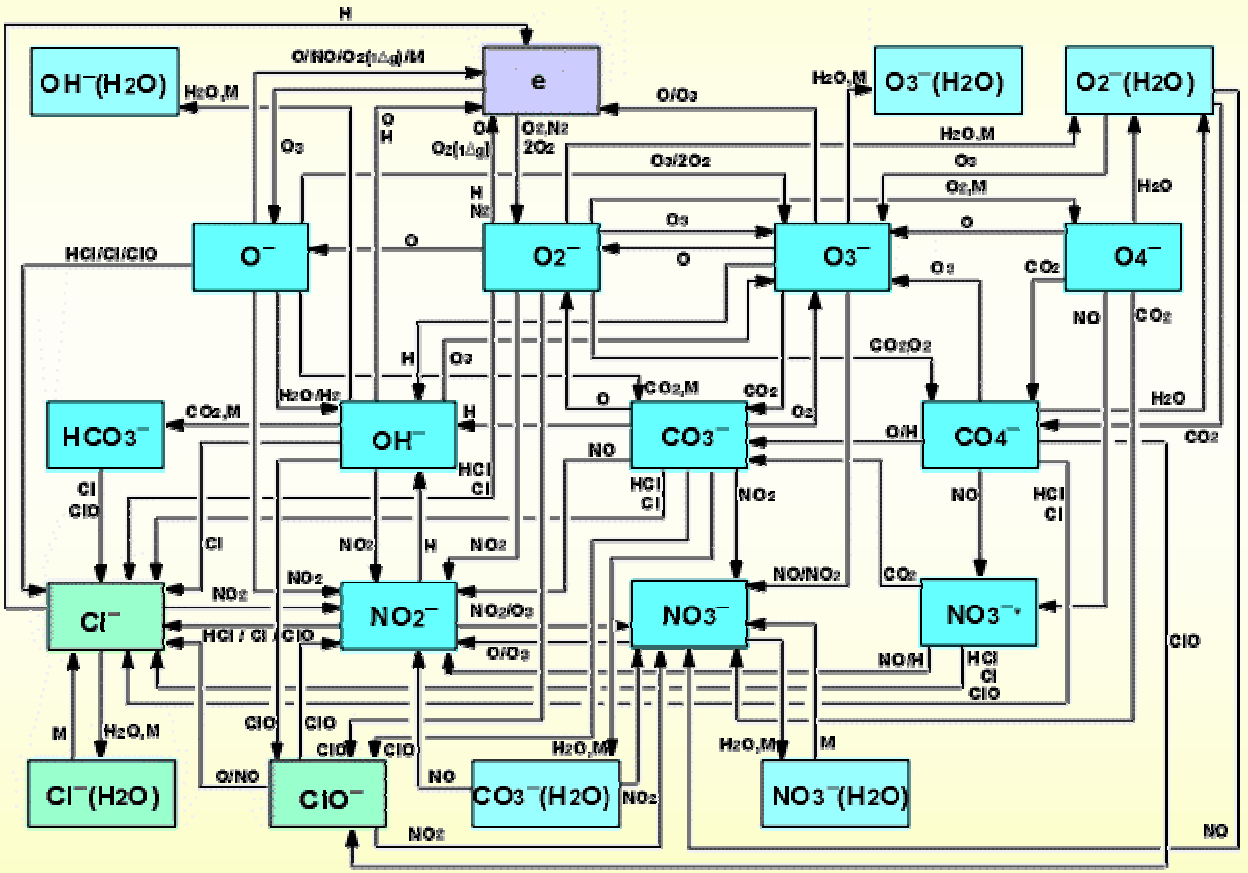
- D-region Model: valid from 50 to 100 km
- Detailed chemistry
  - 56 ions (37 positive, 19 negative)
  - 400+ reactions included
  - 103-ion version under preparation
- Steady state or time-dependent
- Well established: see, e.g., STEP Handbook of Ionospheric Models

SIC - Positive Ion Chemistry



Positive ion reaction scheme

SIC - Negative Ion Chemistry



Negative ion reaction scheme

EISCAT

- European Incoherent Scatter Scientific Association
- Tristatic IS Radars
  - Tromsø, Norway
  - Kiruna, Sweden
  - Sodankylä, Finland
- New: Svalbard, Norway
- Members UK, Germany, France, Japan, Norway, Sweden, Finland

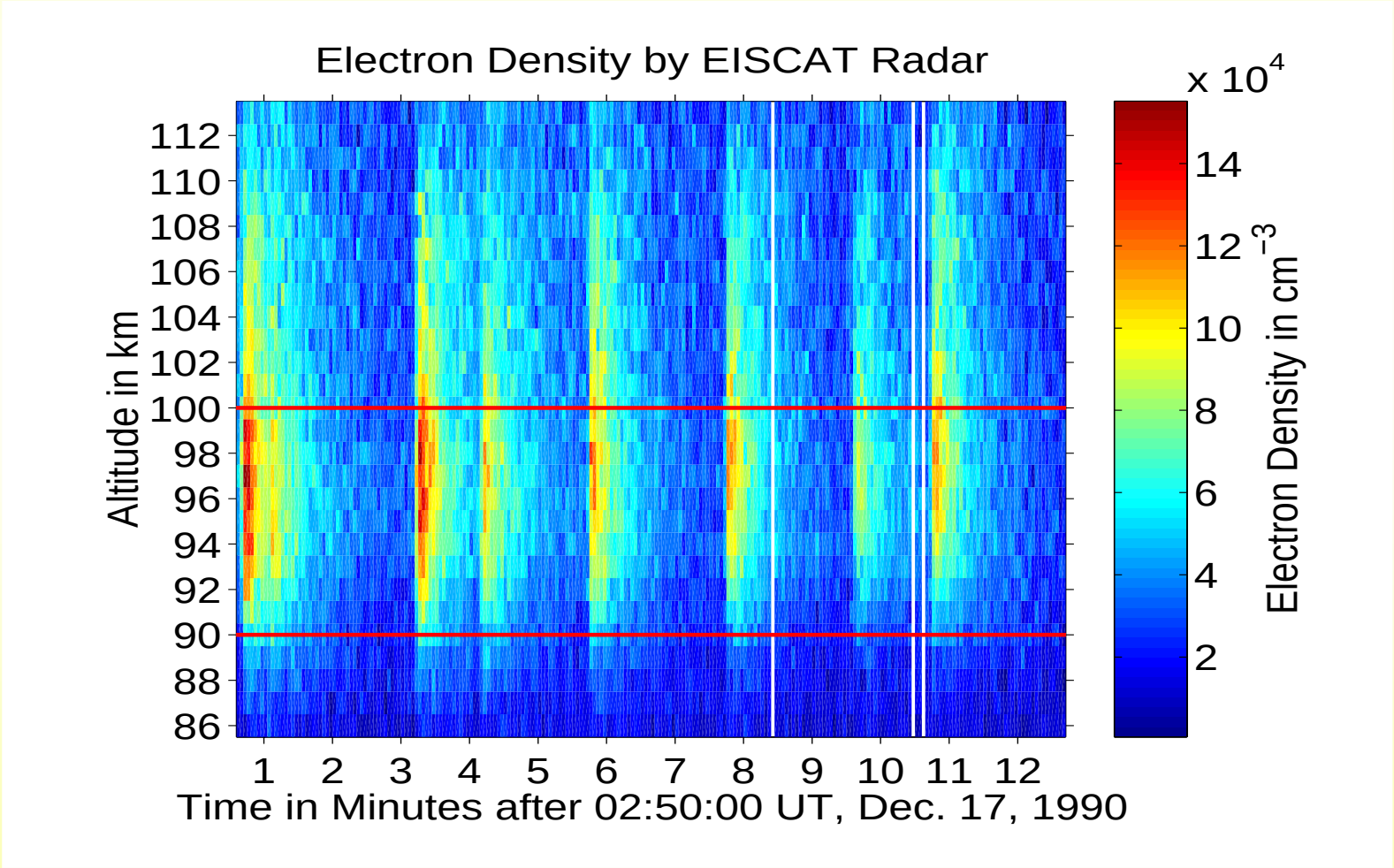
Photo: Jyrki Manninen

Observed Event

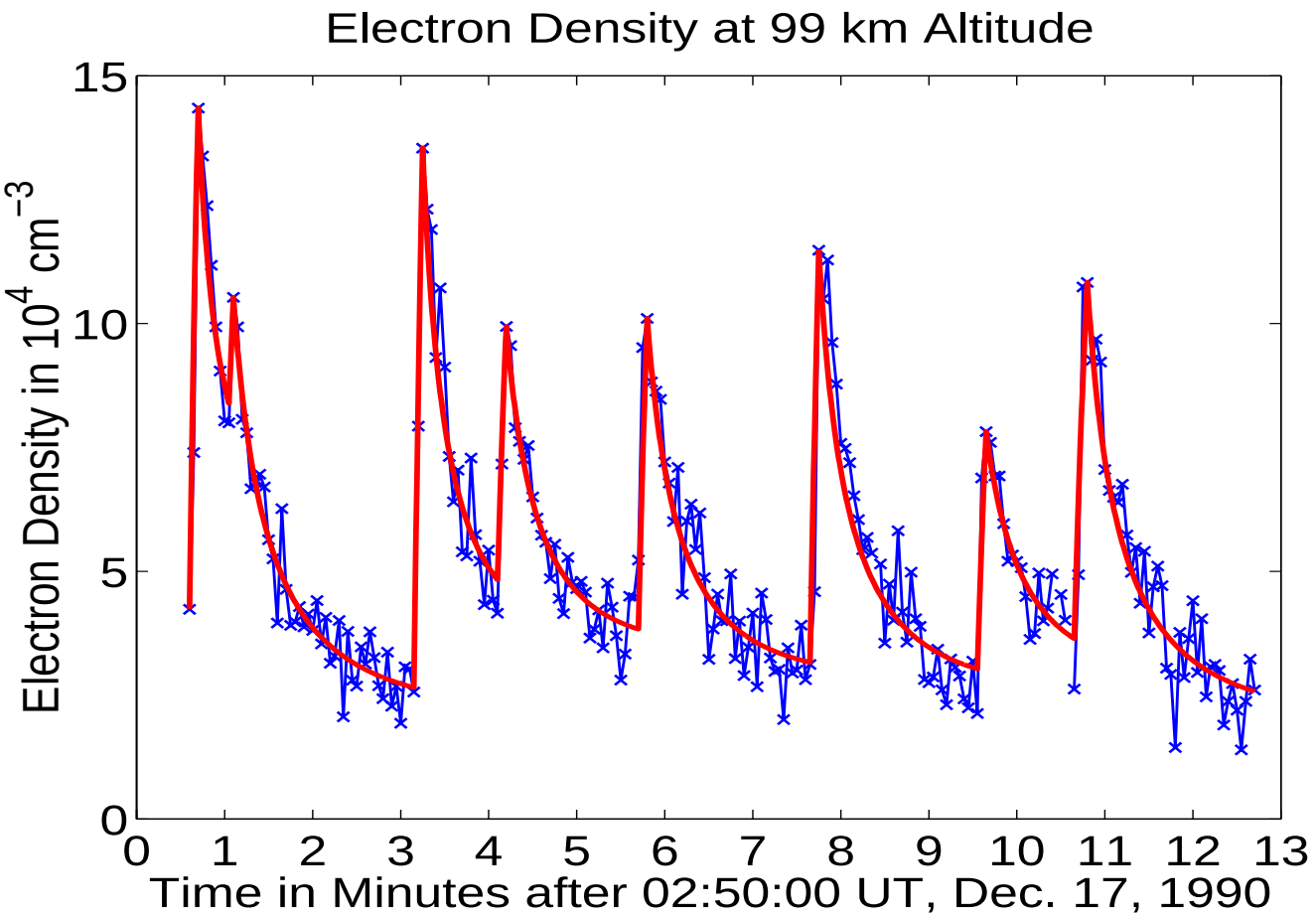
- Time:
  - December 17, 1990, 02:50 UT to 03:03 UT
- Experiment:
  - EISCAT Tromsø, UHF Radar
  - Finnish-designed PULSE experiment
  - High resolution: 0.2 s / 1.03 km
- Photometer data of same time resolution shows pulsating aurora.

Impulsive Precipitation Events

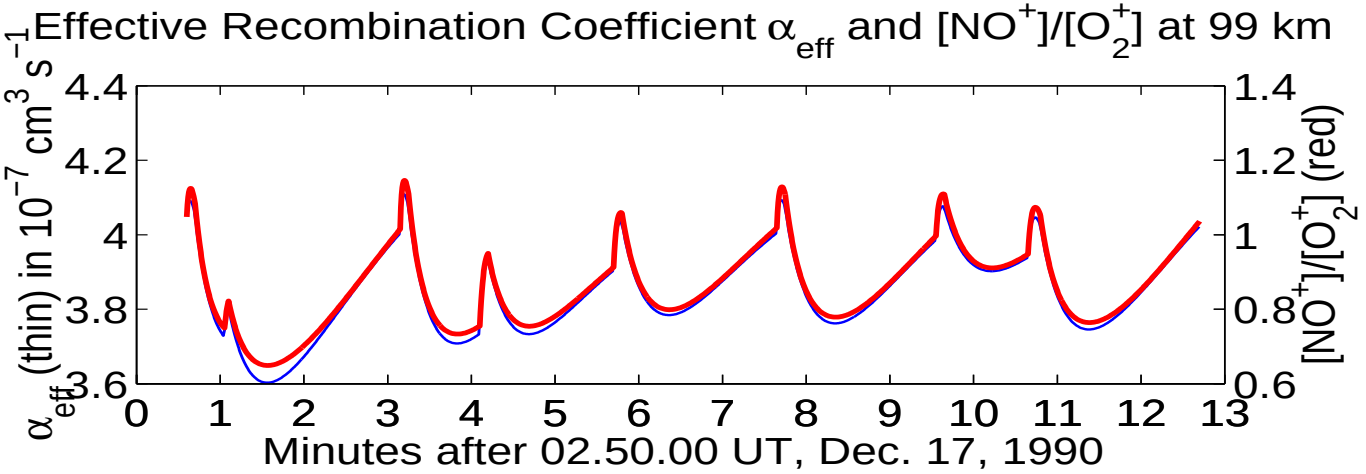
EISCAT “Pulse” on December 17, 1990

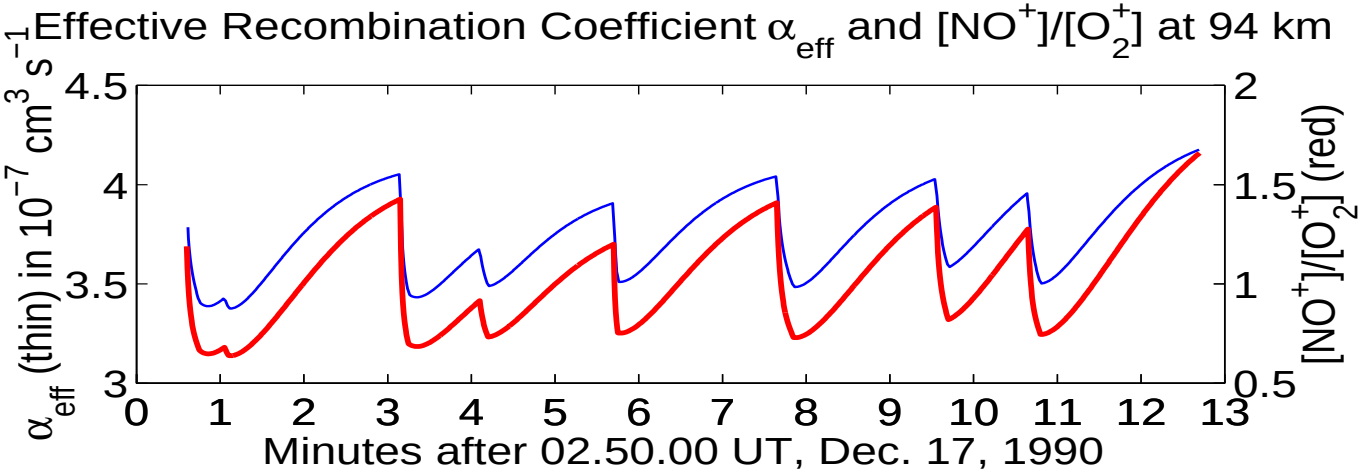


EISCAT Data & SIC Model



α_{eff} and $[NO^+]/[O_2^+]$ 99 km and 94 km

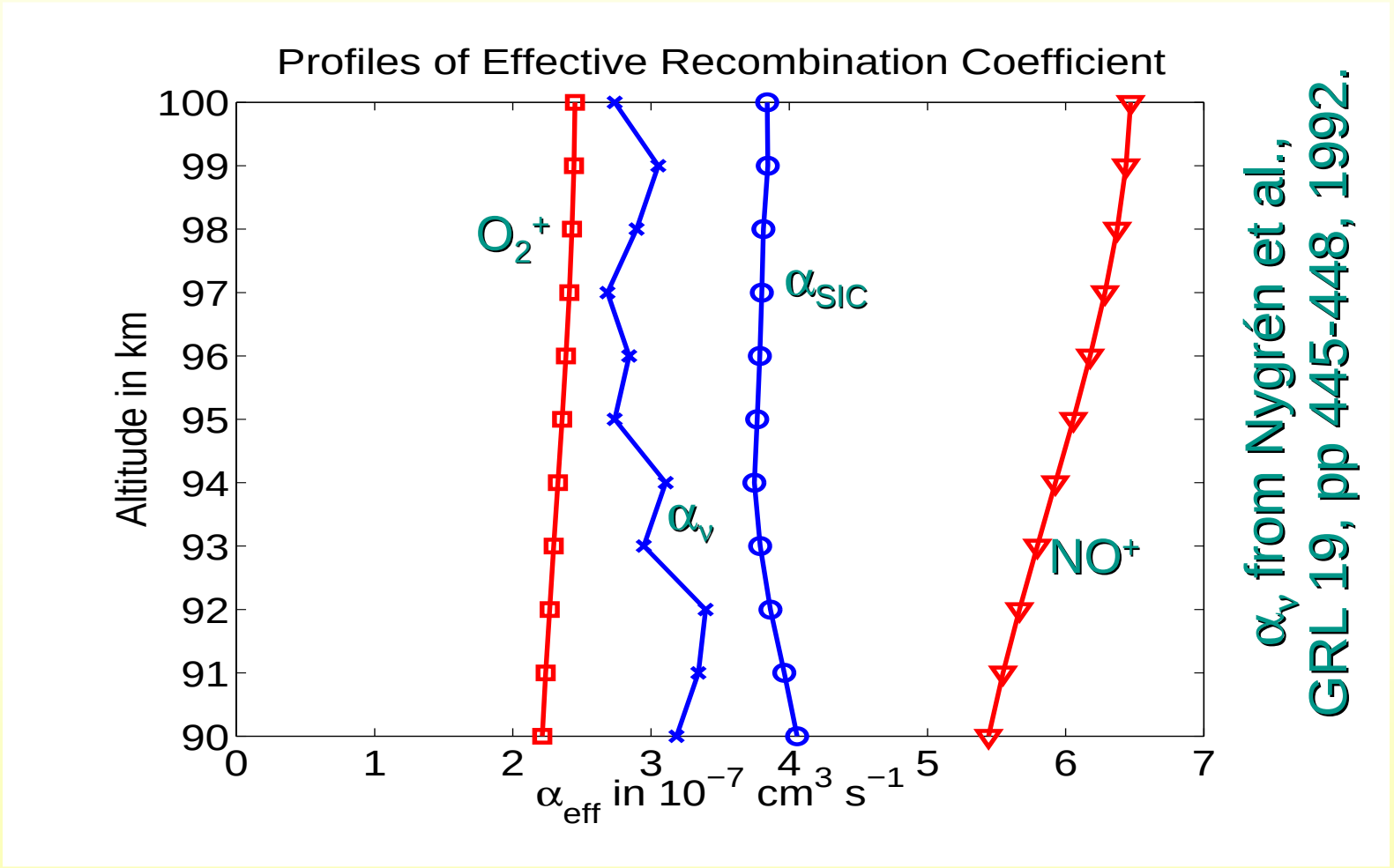




$[NO^+]/[O_2^+]$ at 99 km

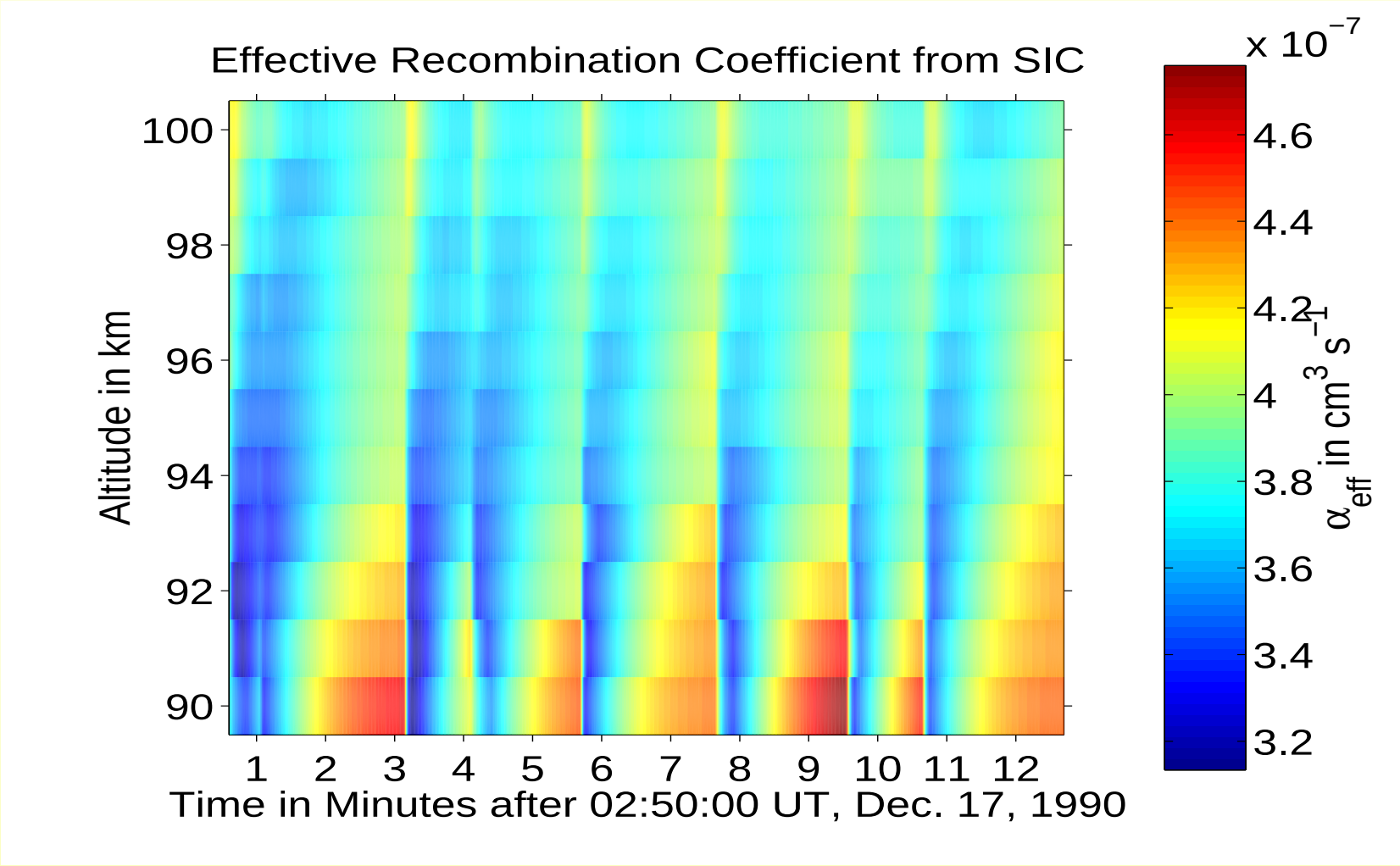
- Expected behaviour: Rapid decrease of $[NO^+]/[O_2^+]$ due to direct ionization of O_2^+ and charge transfer $N_2^+ + O_2 \rightarrow N_2 + O_2^+$.
- Modelled result:
  - At 94 km: as expected.
  - At 99 km: intermediate increase of $[NO^+]/[O_2^+]$.
- If there are high abundances of neutral atomic oxygen, then more NO^+ ions are formed due to the fast reaction $N_2^+ + O \rightarrow NO^+ + N$.

Profiles of Effective Recombination Coefficient

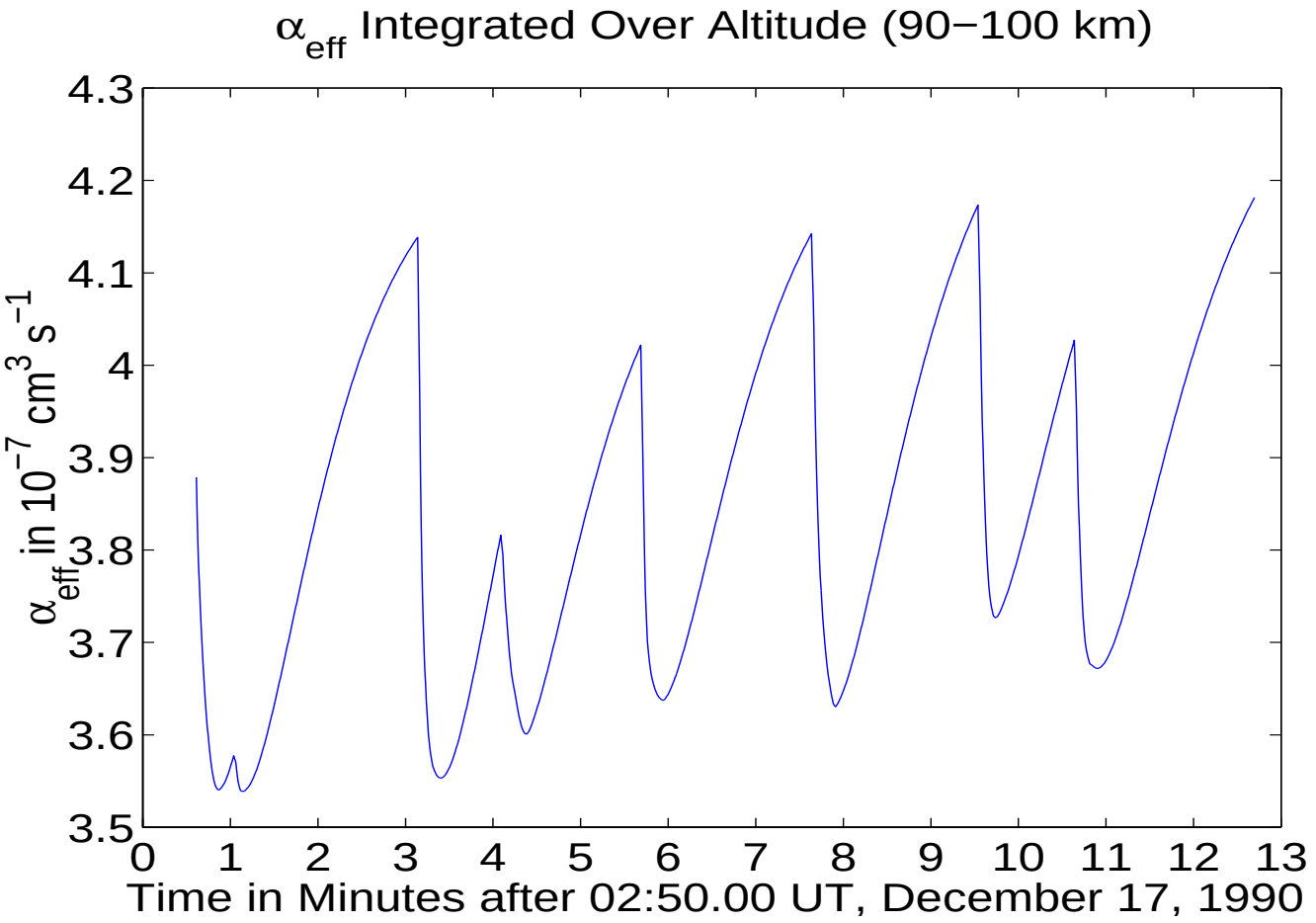


Eff. Recombination Coefficient

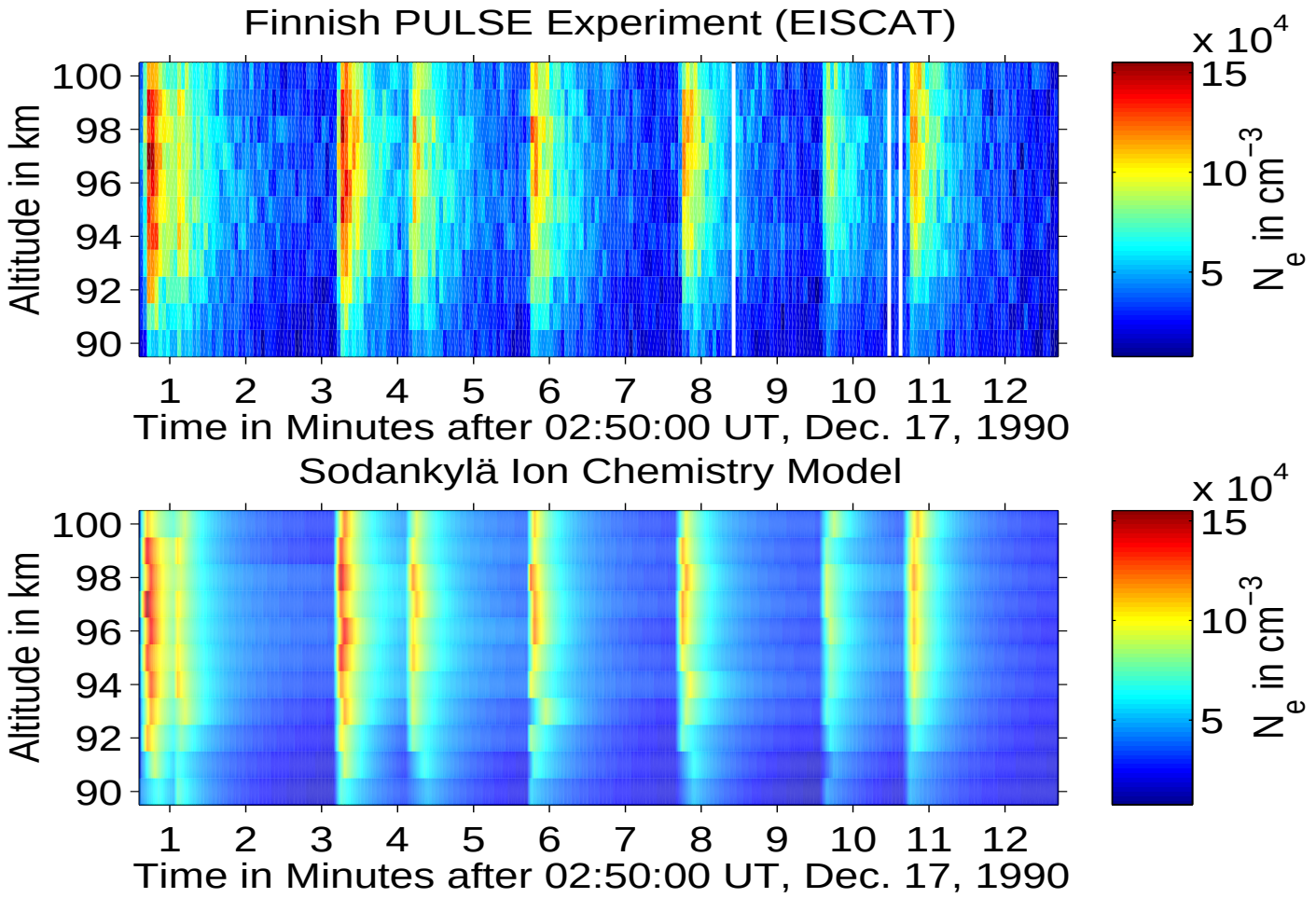
SIC Model Results for α_{eff}



Gradual Increase of α_{eff}



Electron Density: Measurement and SIC Model



Conclusions

- Effective Recombination Rate is not constant, it varies during precipitation.
- Variation is between ±5% and ±10% or on the average 0.3×10^{-7} cm^3 s^{-1}.
- Different relative abundances of neutral atomic oxygen lead to different behaviour of α_{eff} at, e.g. 94 km and 99 km altitude.
- α_{eff} increases gradually throughout the series of precipitation bursts, indicating a cumulative response.