Odd Nitrogen Variability Caused by Energetic Electron Precipitation: What Have We Learned from MIPAS?

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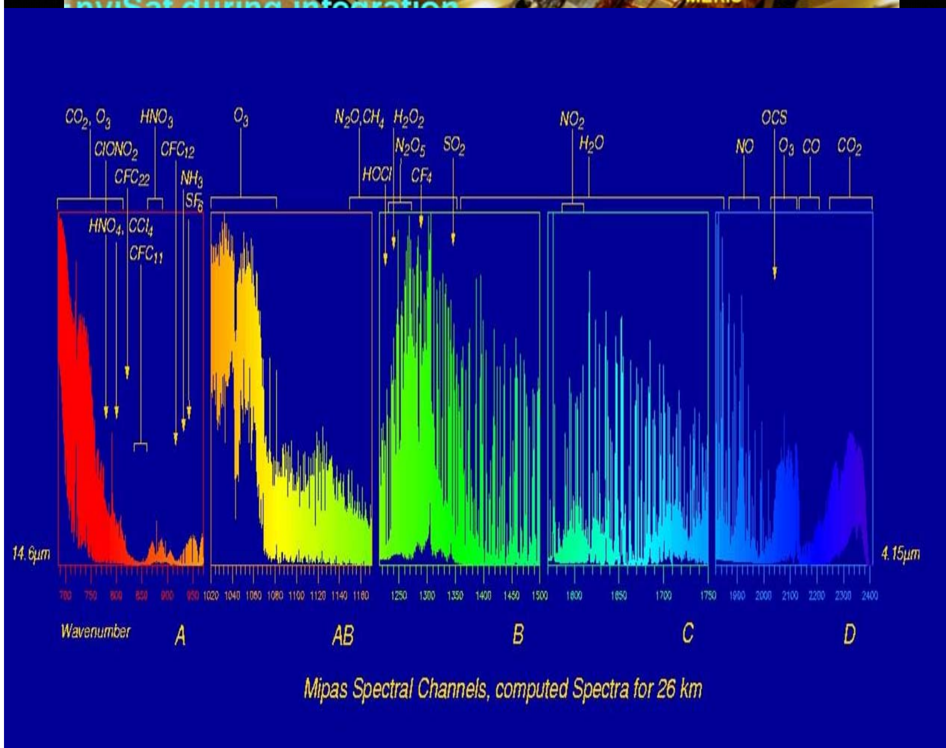
HEPPA 2009, Boulder, CO
Indirect EPP effects
Thursday, 08/10/2009
B. Funke (bernd@iaa.es)

The MIPAS instrument

Michelson Interferometer for Passive Atmospheric Sounding

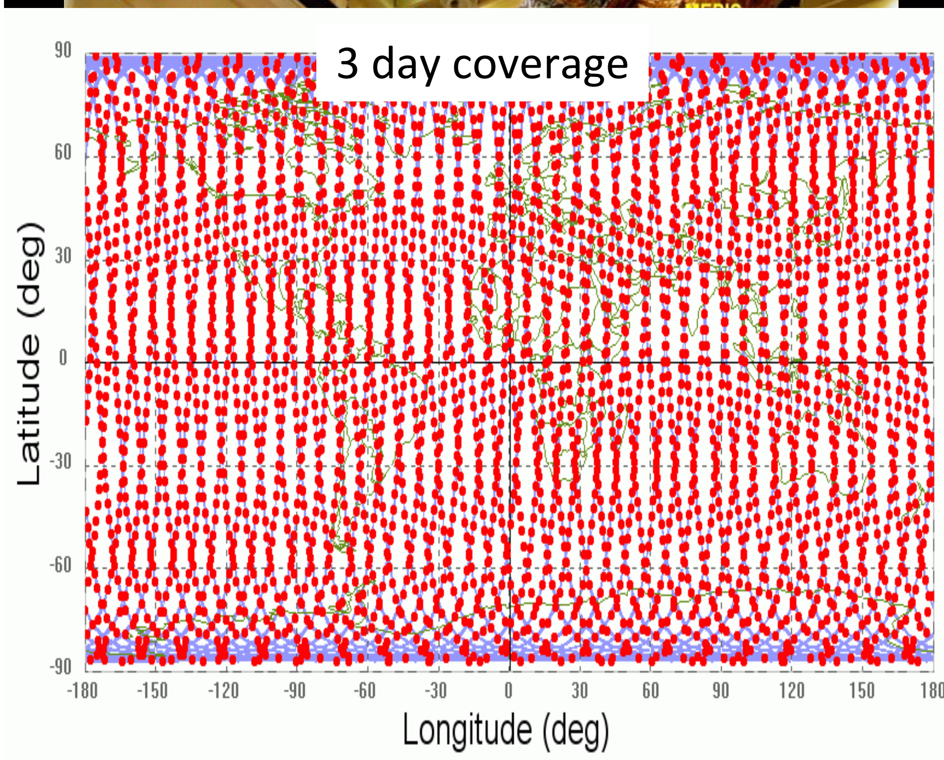


Mipas Spectral Channels, computed Spectra for 26 km

- Launch: **1 March 2002** on board ENVISAT (sun-synchronous polar orbit, 98.5°).
- Spectra at 4.15-14.6 µm (685- 2410 cm^{-1}) with 0.035 cm^{-1} (0.0625 cm^{-1}) resolution.
- Sensitivity: 4-30 nW/(cm^2 sr cm^{-1}).
- Radiometric error: 1-3 %
- Limb, altitude coverage: 6-68 km @ 3 km steps in 85 s. (nominal mode), 20-100 km (middle atmosphere mode), 40-170 km (upper atmosphere mode
- Global coverage in latitude (polar night!)
- 72 scans/orbit; ~1000 scans/day

The MIPAS instrument

Michelson Interferometer for Passive Atmospheric Sounding



- Launch: **1 March 2002** on board ENVISAT (sun-synchronous polar orbit, 98.5º).
- Spectra at 4.15-14.6 μm (685- 2410 cm^{-1}) with 0.025 cm^{-1} (0.0625 cm^{-1}) resolution
- Sensitivity: 4-30 nW/(cm^2 sr cm^{-1}).
- Radiometric error: 1-3 %
- Limb, altitude coverage: 6-70 km @ 3 km steps in 85 s. (nominal mode), 20-100 km (middle atmosphere mode, each 10 days), 40-170 km (upper atmosphere mode , each 10 days)
- Global coverage in latitude (polar night!)
- 72 scans/orbit; ~1000 scans/day

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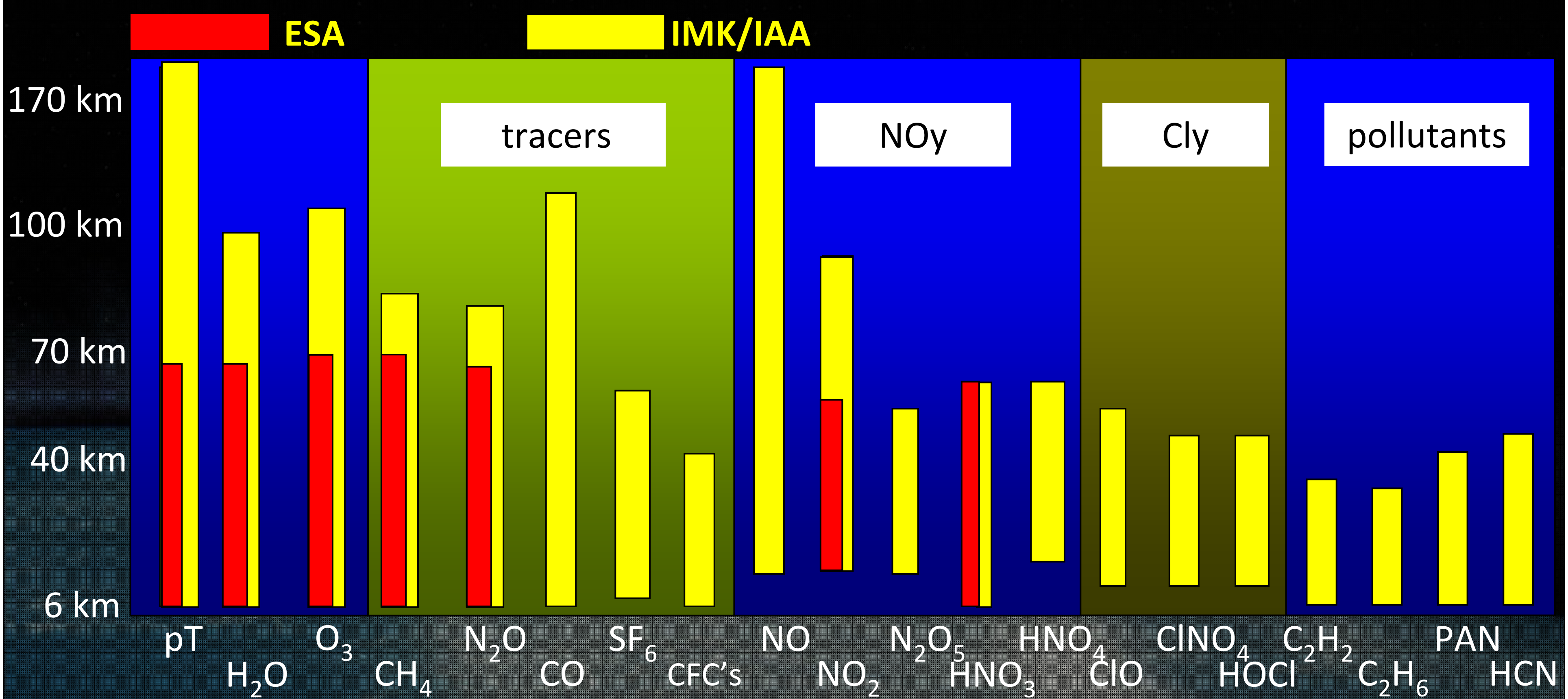
IMK/IAA MIPAS data products



- Data access via web: http://www-imk.fzk.de/asf/ame/envisat-data/
- Annual "IMK/IAA MIPAS Data User meeting" in Karlsruhe/Germany or Granada/Spain

Next meeting:
13-15 October 2009
at IMK/Karlsruhe/Germany

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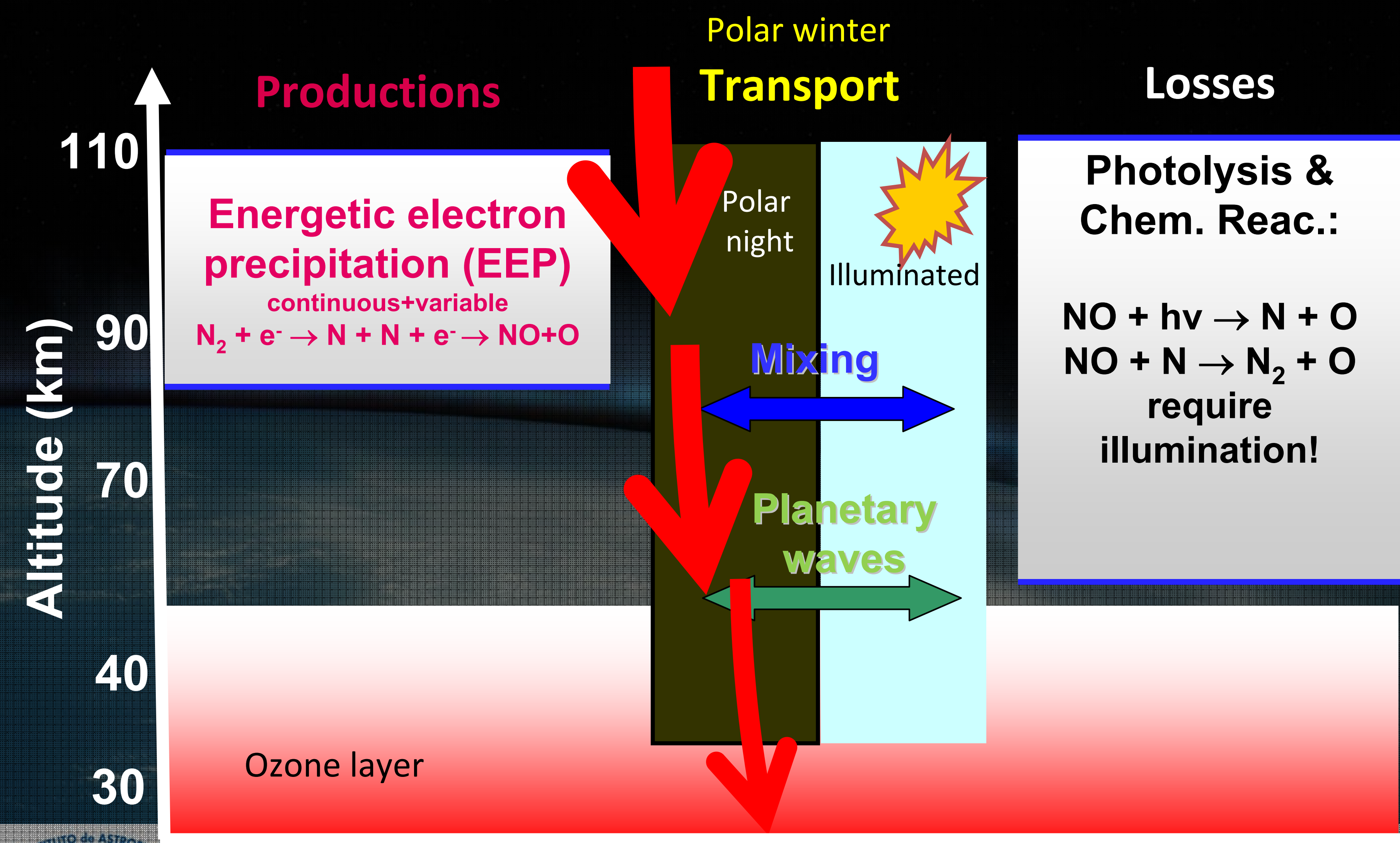
EEP: NOx polar winter descent



ENVISAT
MIPAS
IMK

5 reasons for MIPAS in EEP research:

1. **Observations at polar night conditions**
2. **Excellent spatial coverage** (compared to solar occultation)
3. **Measures both NOx species ($NO+NO_2$)**
4. **Measures secondary EPP products** (HNO_3, N_2O, $ClONO_2$, N_2O_5, ClO, $HOCl$, $BrONO_2$)
5. **Simultaneous measurements of stratospheric and mesospheric dynamical tracers** (CO, CH_4)

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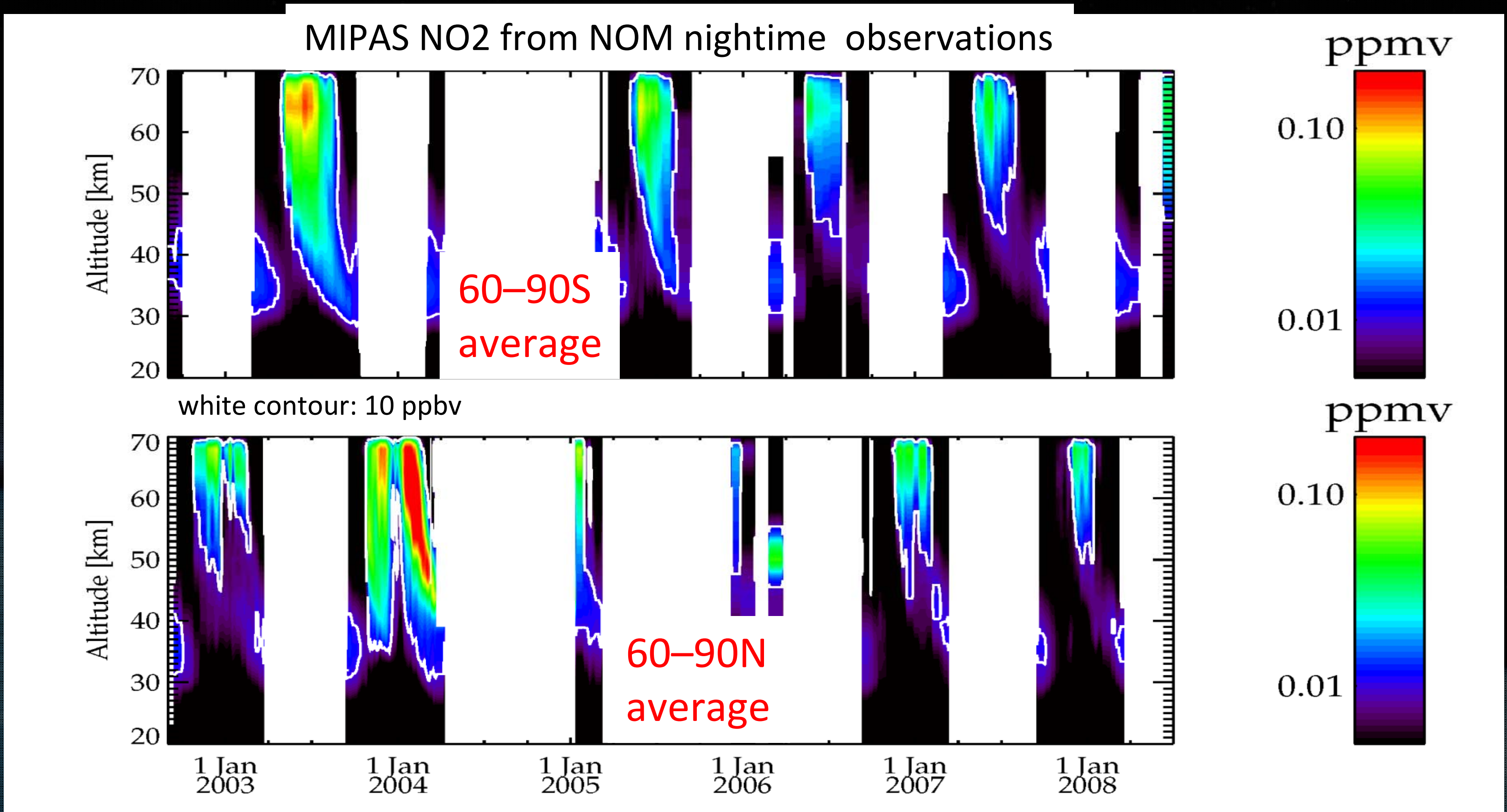
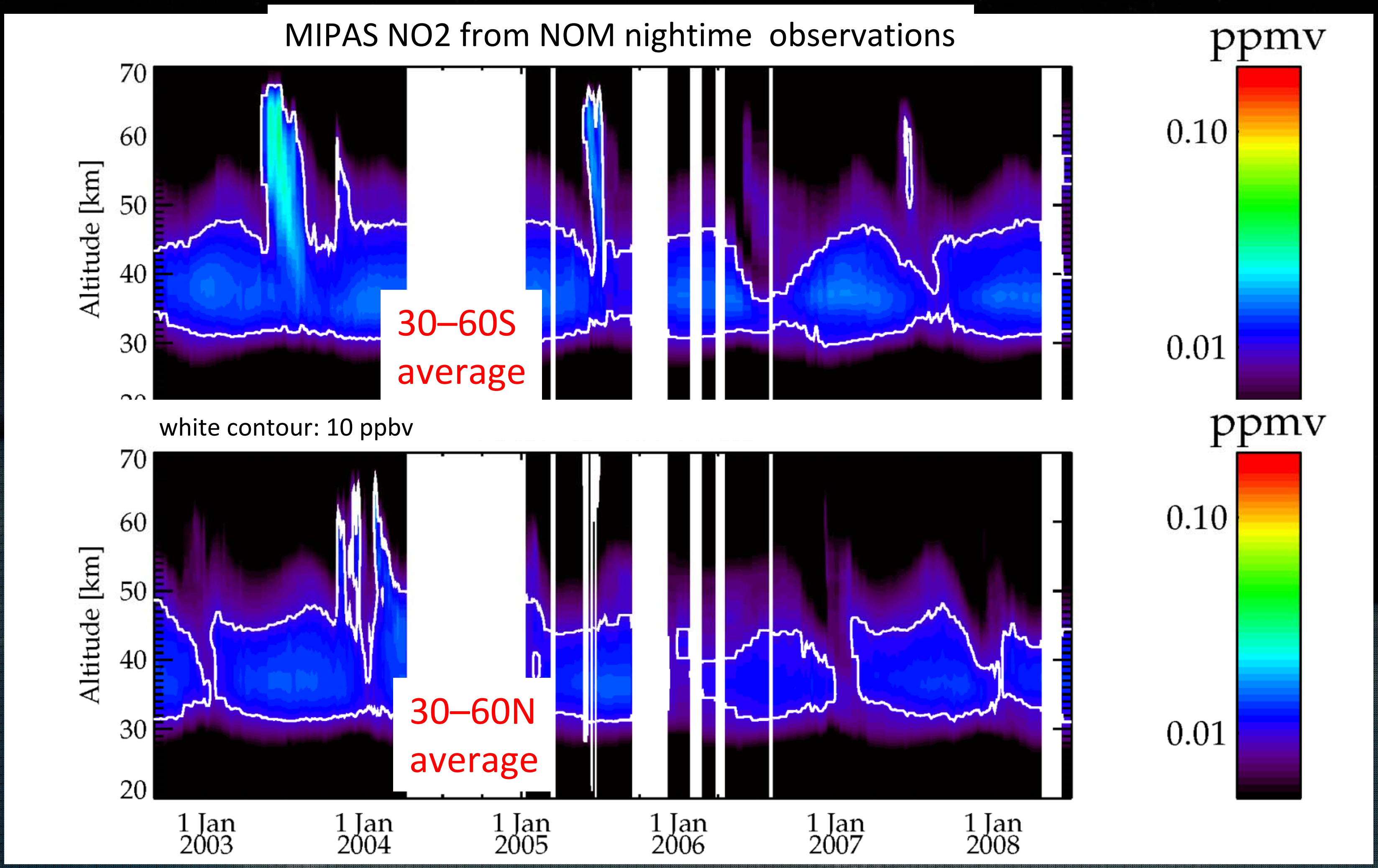
EEP: polar winter NOx descent

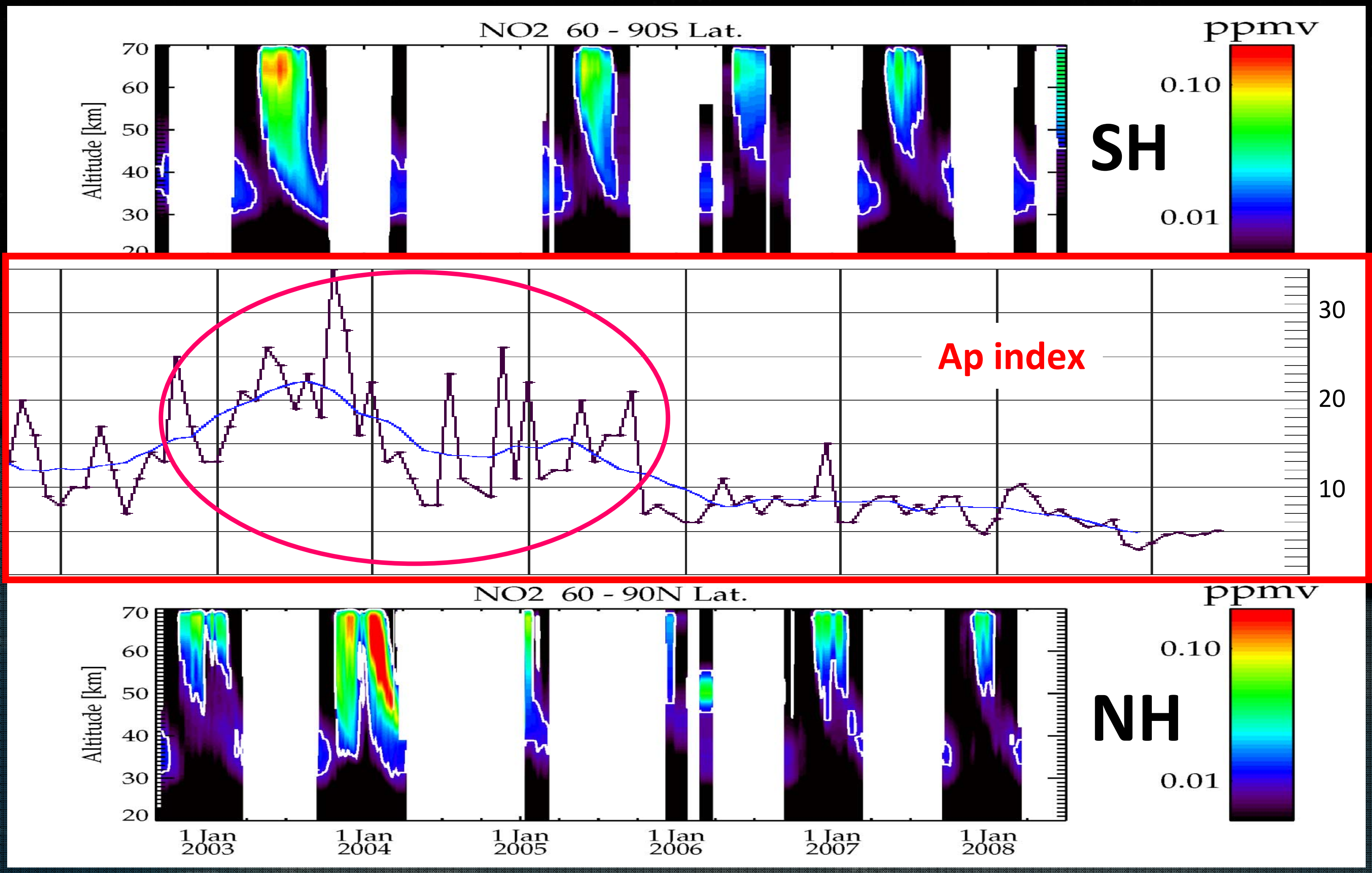


- strongest EEP-NOX descent in 2003-2004 winters
- higher variability in NH winters

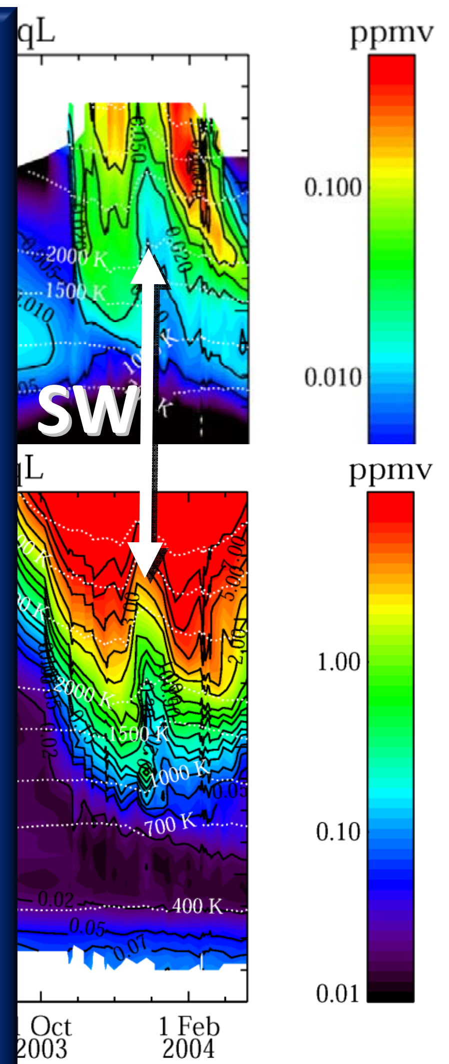
Energetic electron precipitation (EEP)



Ap dependence of NOx enhancements



Dynamical modulations: NO2 and CO



GEOPHYSICAL RESEARCH LETTERS, VOL. 34, L07813, doi:10.1029/2006GL027518, 2007

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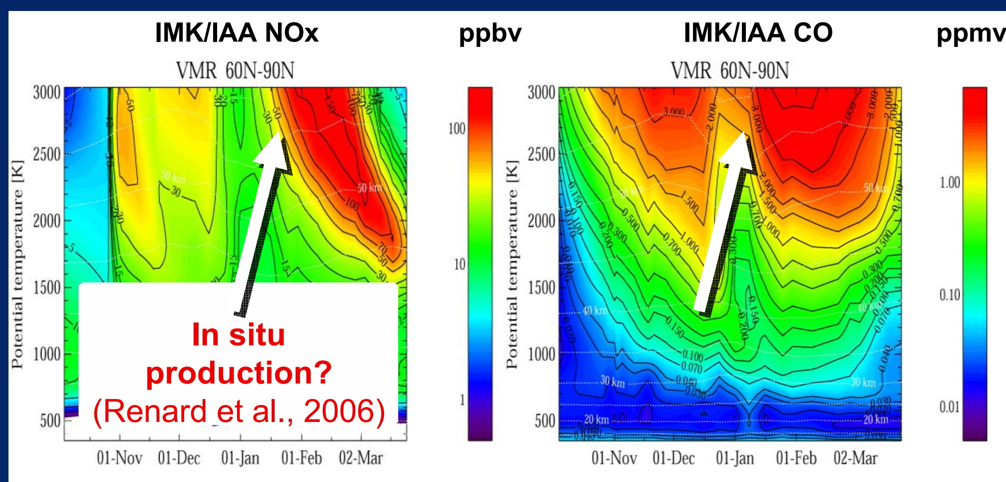
Comment on "Origin of the January–April 2004 increase in stratospheric NO_2 observed in northern polar latitudes" by Jean-Baptiste Renard et al.

B. Funke,[1] M. López-Puertas,[1] H. Fischer,[2] G. P. Stiller,[2] T. von Clarmann,[2] G. Wetzel,[2] B. Carli,[3] and C. Belotti[3]

Extraordinary NOx enhancements in January 2004 (NH) caused by rapid **descent** (1200 m/day) from the MLT (not in situ production)



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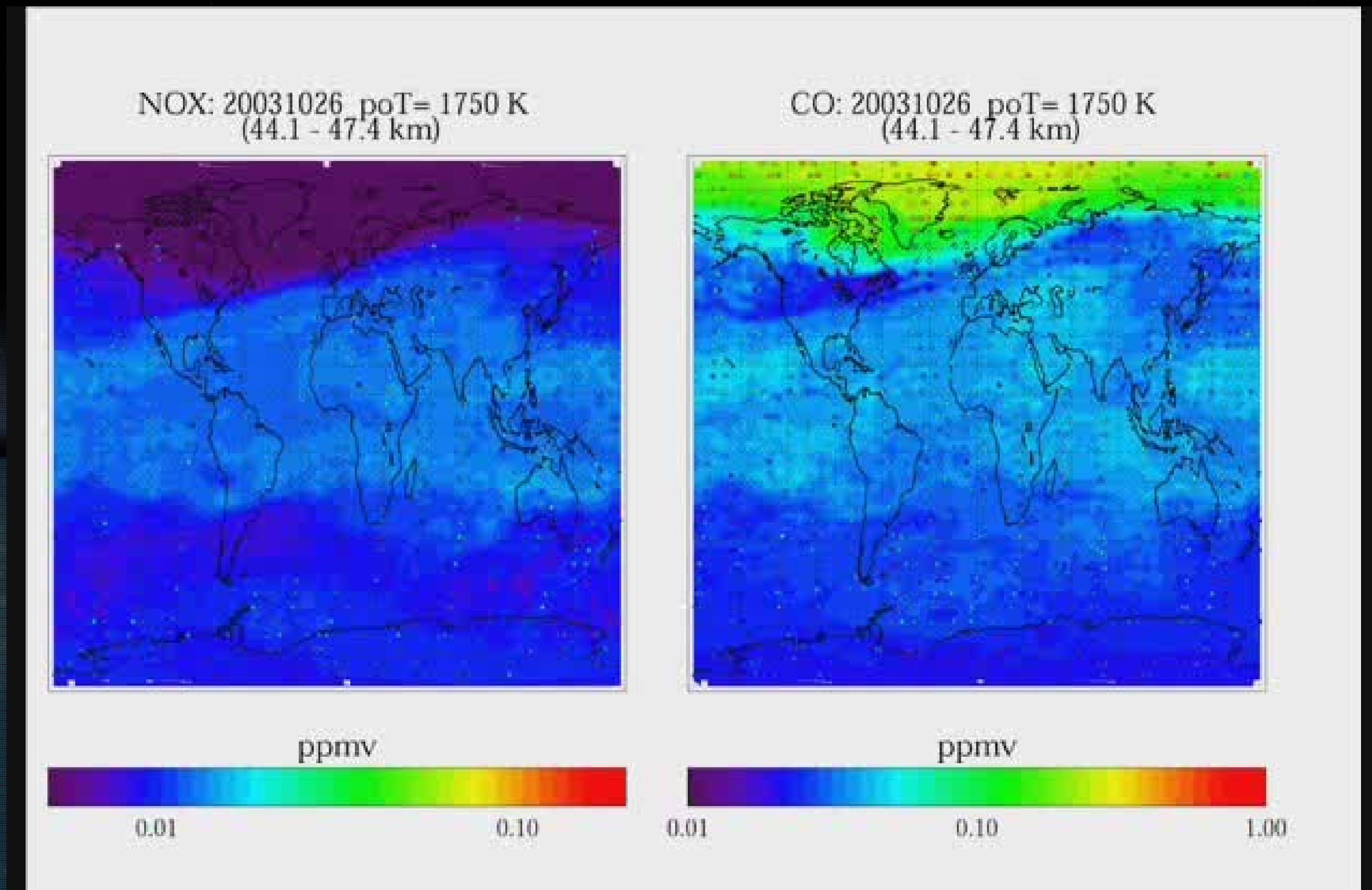
NOx and CO in 2003/2004

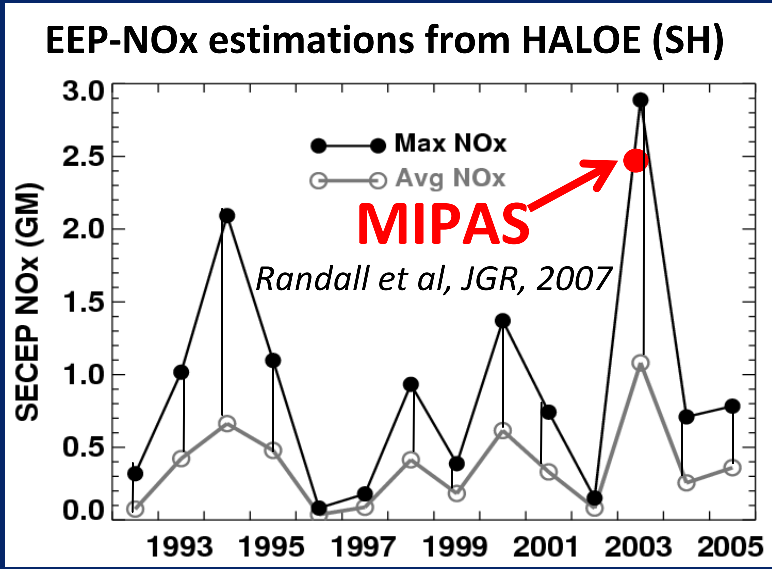


Quantification of strat. EEP-NOx

Stratospheric deposition of EEP-generated NOx during 2003/2004

- 2003 Antarctic : **2.4 GM**
  Funke et al. JGR, 2005

- 2004 Arctic : **2.3 GM**
  (1.5 EEP, 0.8 SPE)
  most NOx deposited above 35 km!



…9% of the annual production by N_2O oxidation!

Secondary EEP effects

2nd HNO_3 maximum at 35 km


JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 110, D20303, doi:10.1029/2005JD006011, 2005

An enhanced HNO_3 second maximum in the Antarctic midwinter upper stratosphere 2003

G. P. Stiller, Gizaw Mengistu Tsidu, T. von Clarmann, N. Glatthor, M. Höpfner, S. Kellmann, A. Linden, R. Ruhnke, and H. Fischer
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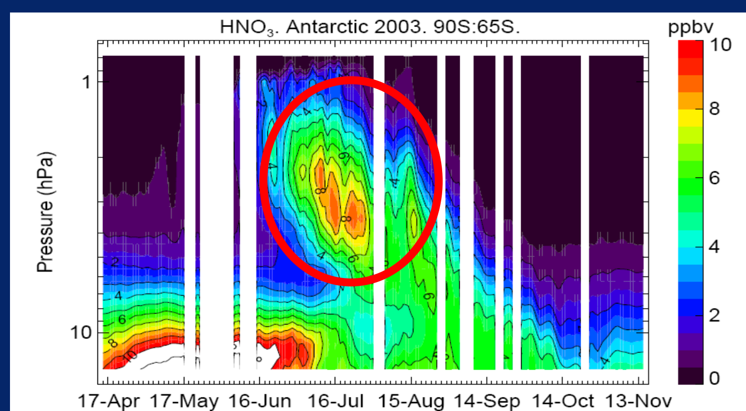
- Caused by descent of EEP-NOx.
- Conversion NOx → HNO_3 requires ion chemistry.



Secondary EEP effects

EEP-related N_2O enhancements

Atmos. Chem. Phys., 8, 5787–5800, 2008
www.atmos-chem-phys.net/8/5787/2008/

Atmospheric Chemistry and Physics

Mesospheric N_2O enhancements as observed by MIPAS on Envisat during the polar winters in 2002–2004

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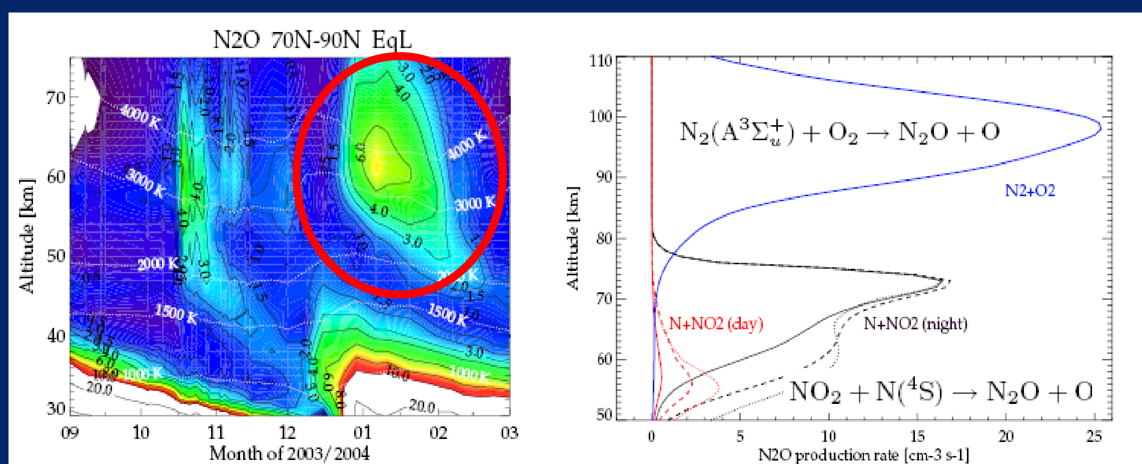
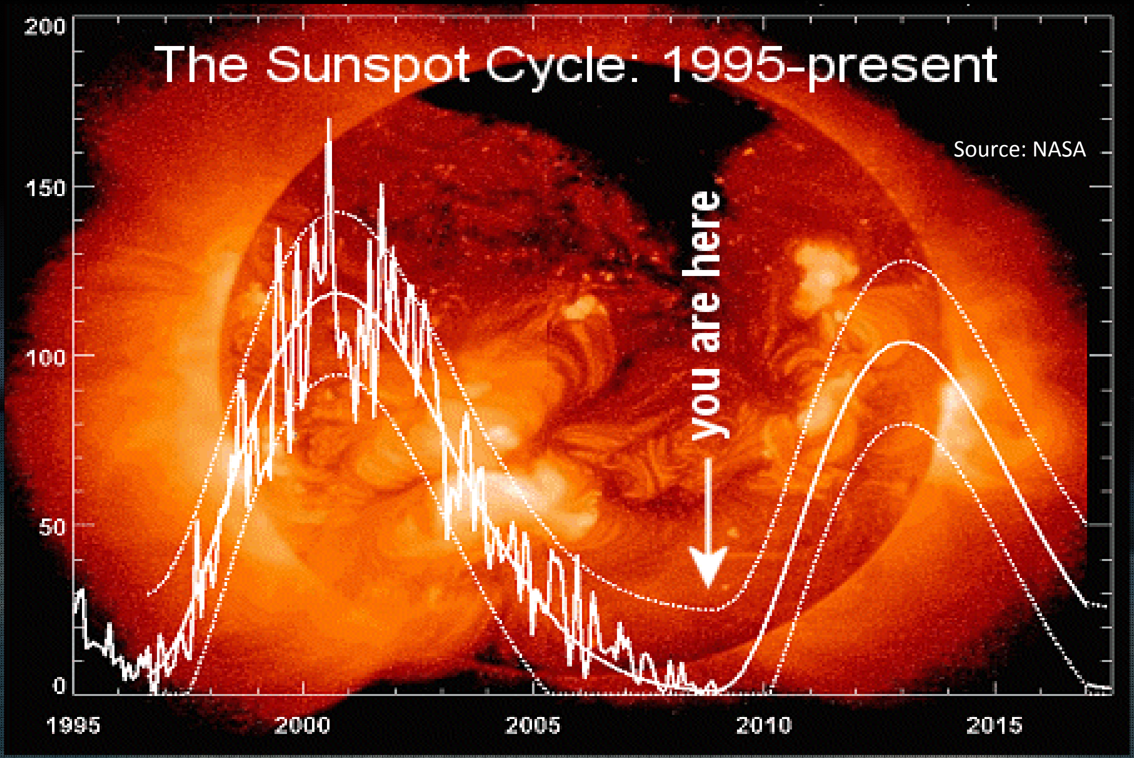
- Caused by $NO_2+N \rightarrow N_2O+O$ below 75 km
- Possible additional contribution of $N_2(A^3\Sigma^+_u)+O_2$



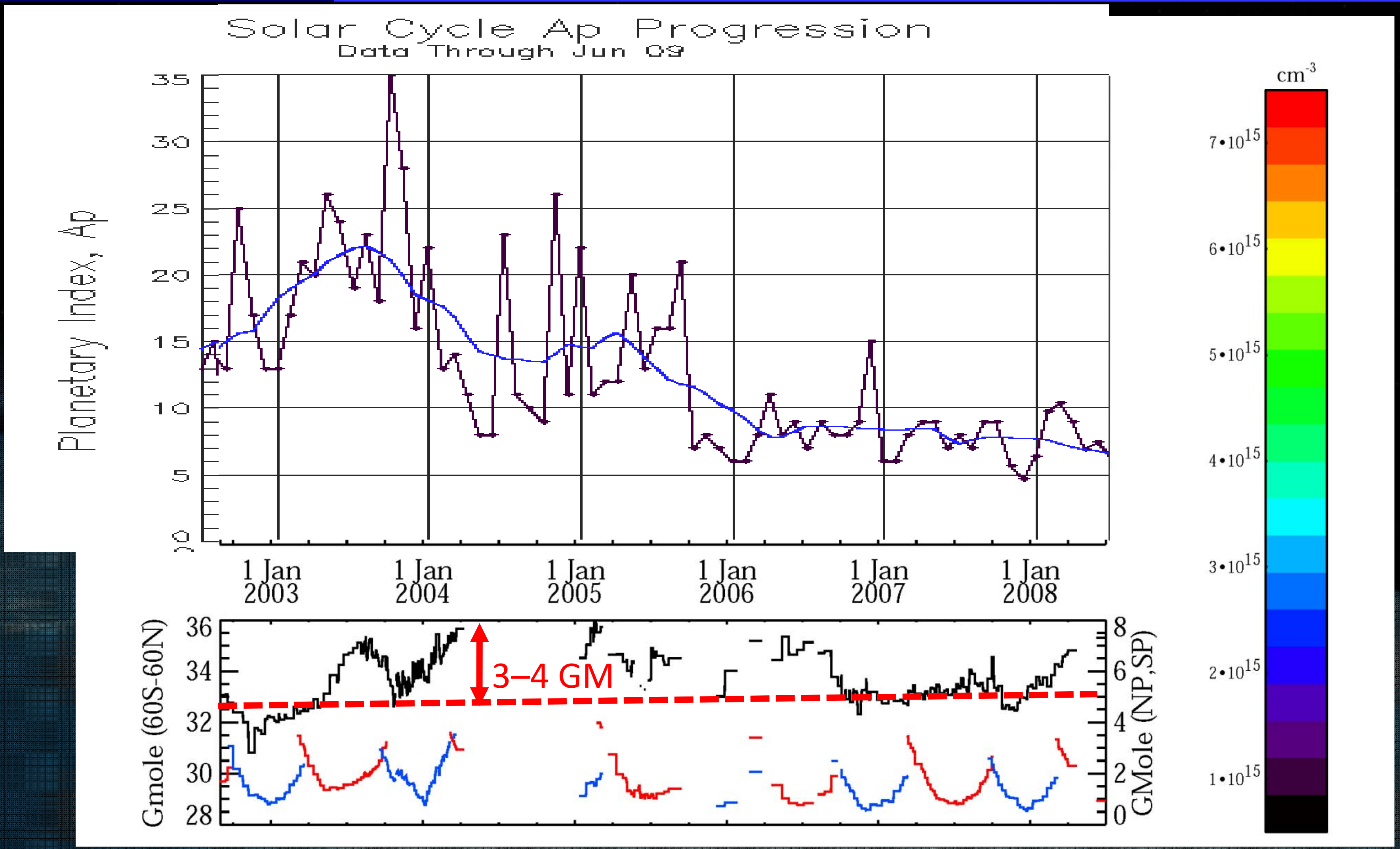
Solar cycle trends in global NOx and NOy



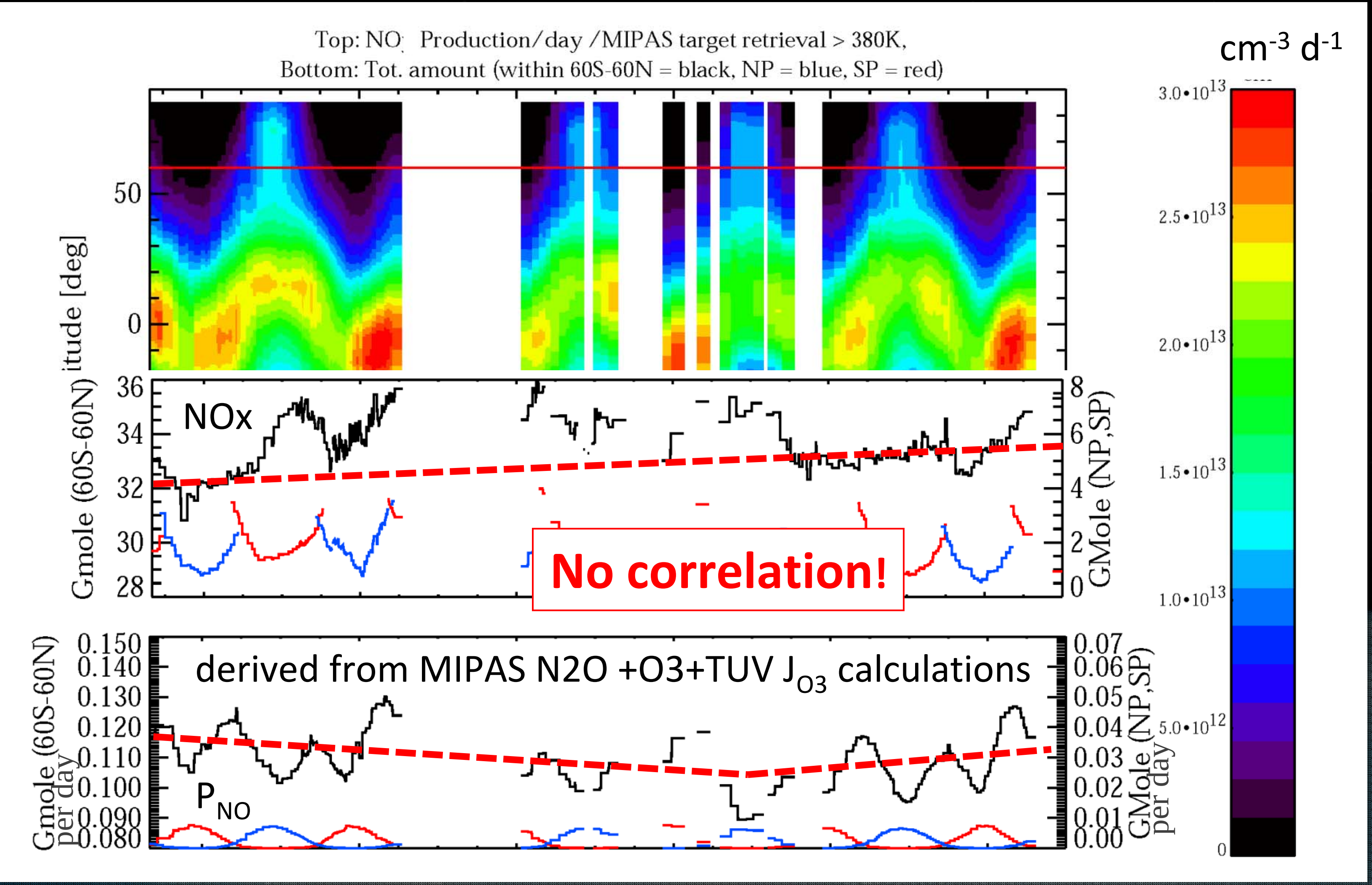
Is there an EEP signal?

(a preliminary analysis....)

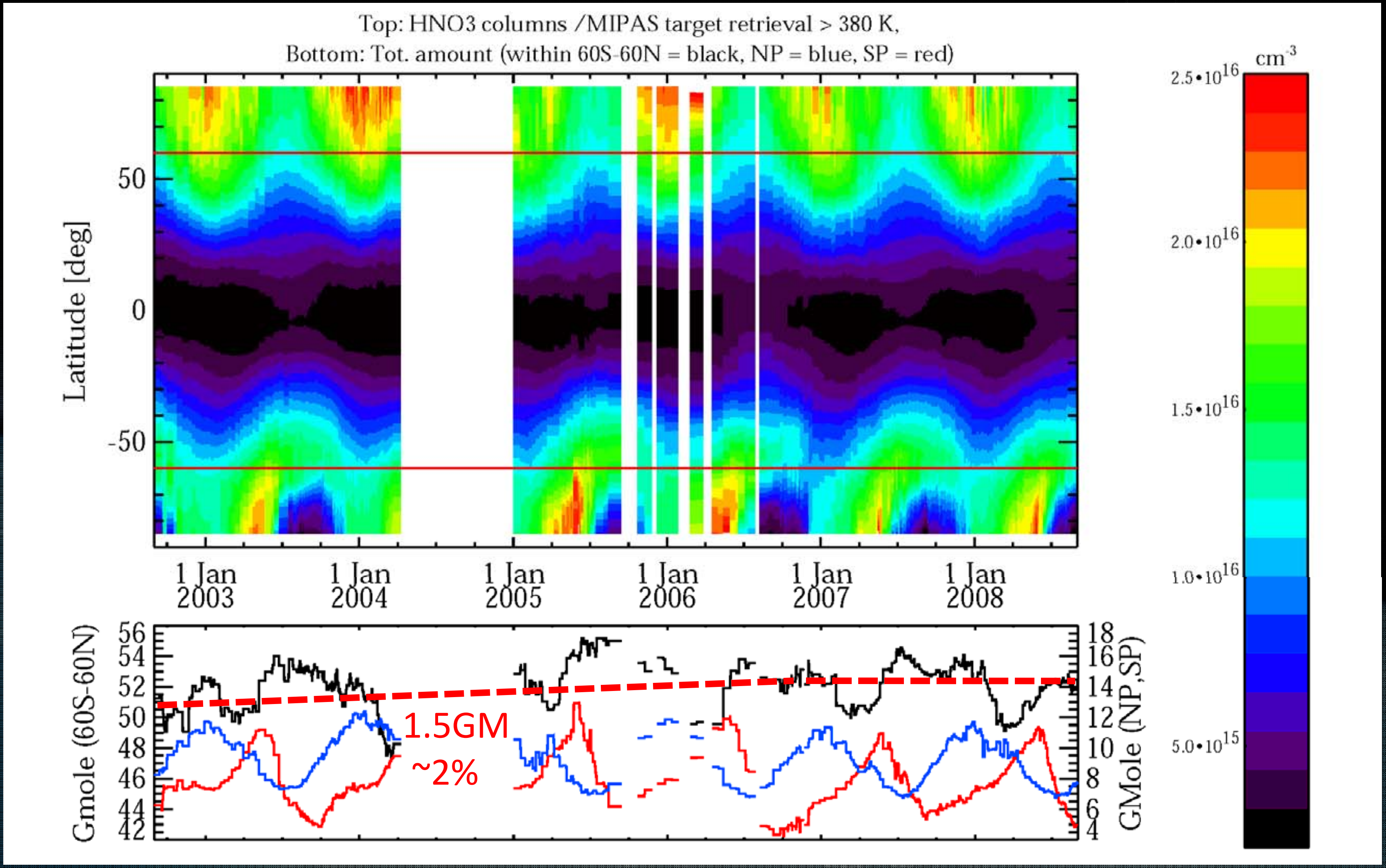
Stratospheric NOx



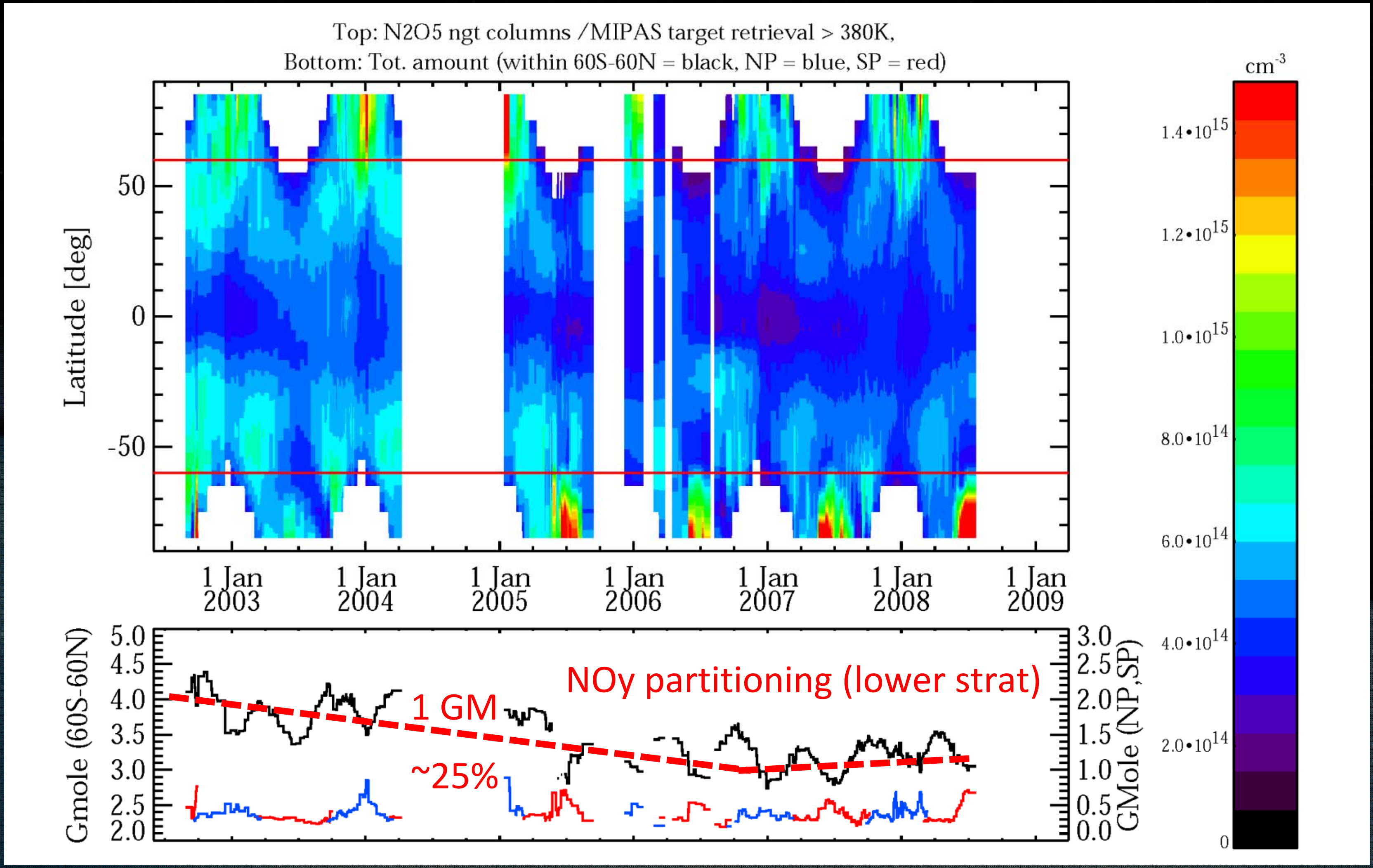
NO production by N2O+O1D



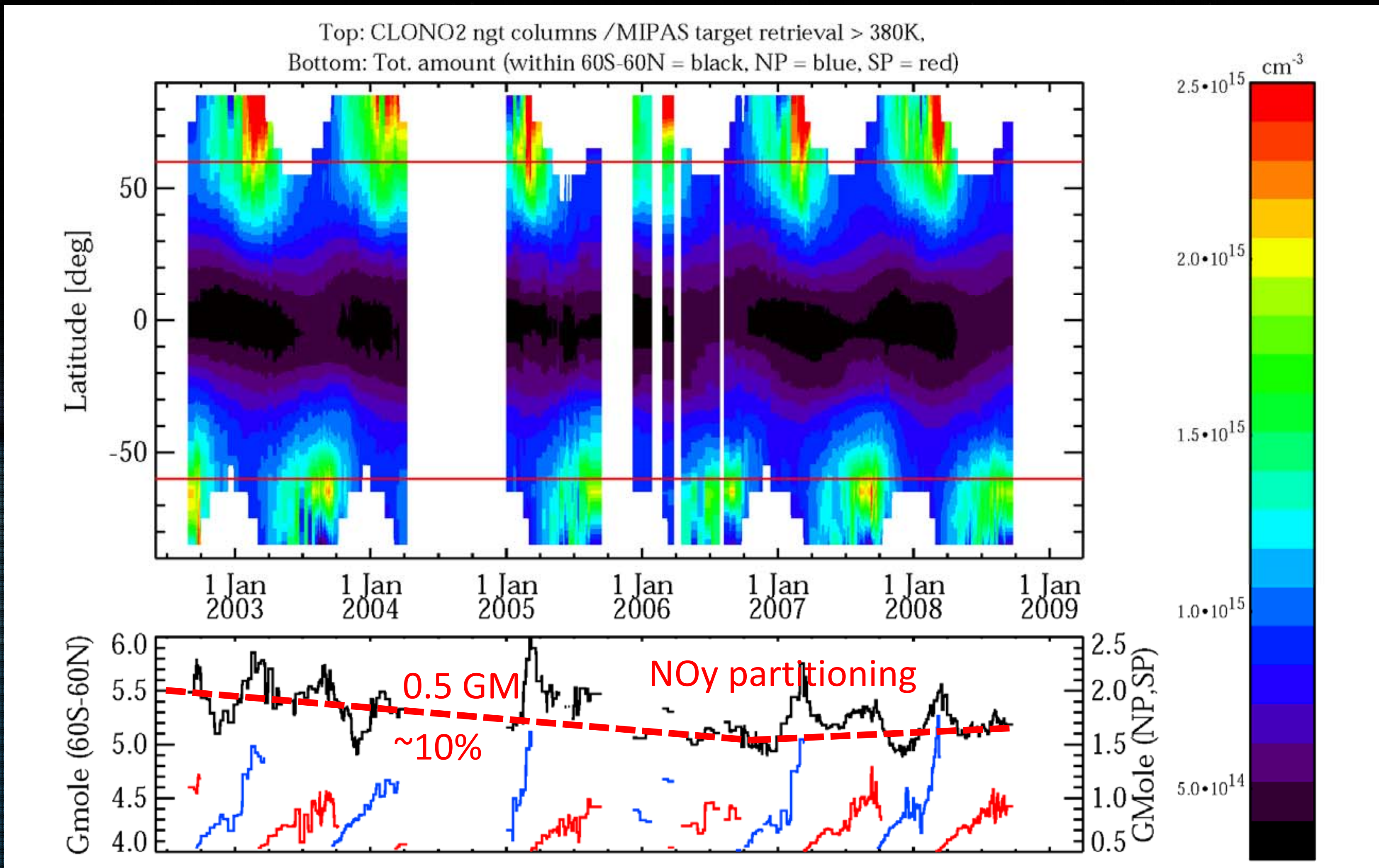
Stratospheric HNO3



Stratospheric N2O5



Stratospheric ClONO2

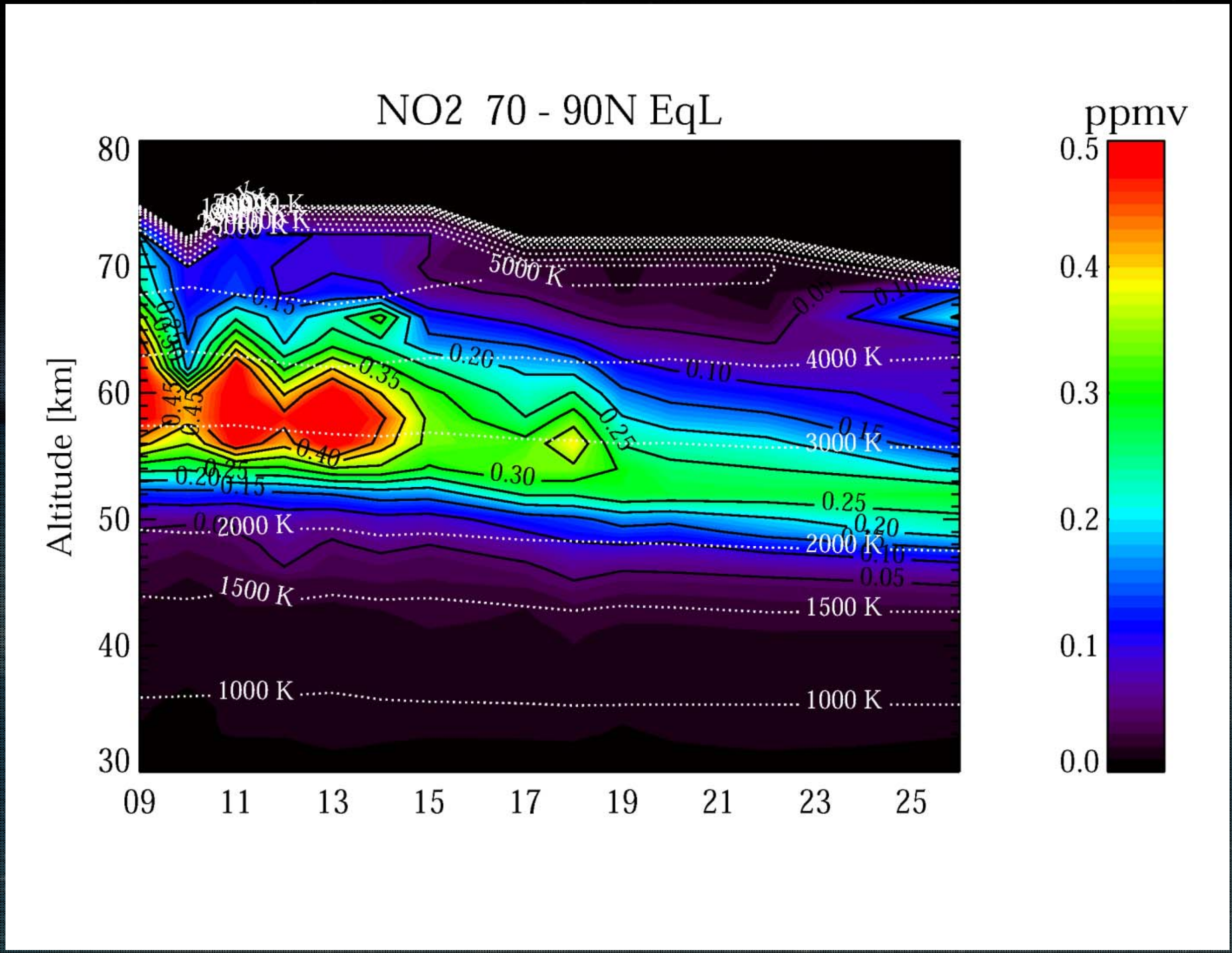


Summary & Conclusions

MIPAS: perfectly suited for EPP studies (global coverage including polar night, simultaneous observations of many species affected by EPP (NO+NO_2, etc), and dynamical tracers)

- Dynamical modulations of EEP NOx descent most pronounced in NH (analysis by means of simultaneous tracer (CO) observations), no EEP-induced stratospheric /lower mesospheric in situ production detected by now.
- Quantification of EEP-NOx deposition into the stratosphere: 9% of N_2O oxidation in 2003/2004
- Identification of EEP-related productions of N_2O and HNO_3
- Solar cycle trends in global NOx and NOy (2002-2008):
  - NOx: 4 GM increase during 2003-2005 most likely due to EEP
  - HNO_3: 2% increase (solarmax to solarmin) due to reduced photolysis
  - N_2O_5 and $ClONO_2$: decreases due to changed paritioning in lower strat (HNO_3)

Thank you!


NO2 70 - 90N EqL
ppmv
Altitude [km]
80
70
60
50
40
30
09
11
13
15
17
19
21
23
25
5000 K
4000 K
3000 K
2000 K
1500 K
1000 K
0.15
0.20
0.35
0.40
0.30
0.25
0.10
0.05
0.5
0.4
0.3
0.2
0.1
0.0