Measurements of Temperature and Nitric Oxide in the Thermosphere from 5.3 μm emission taken by MIPAS on Envisat

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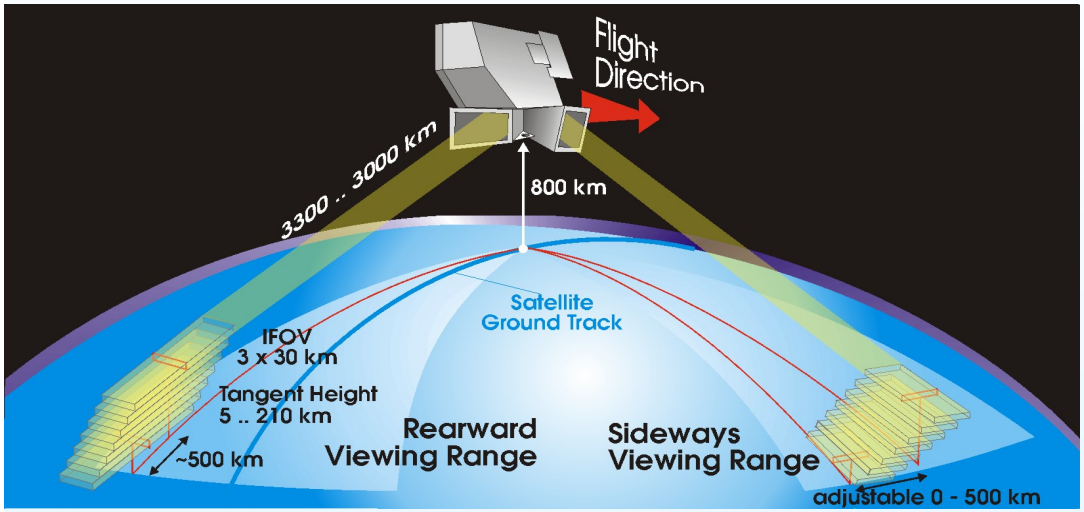
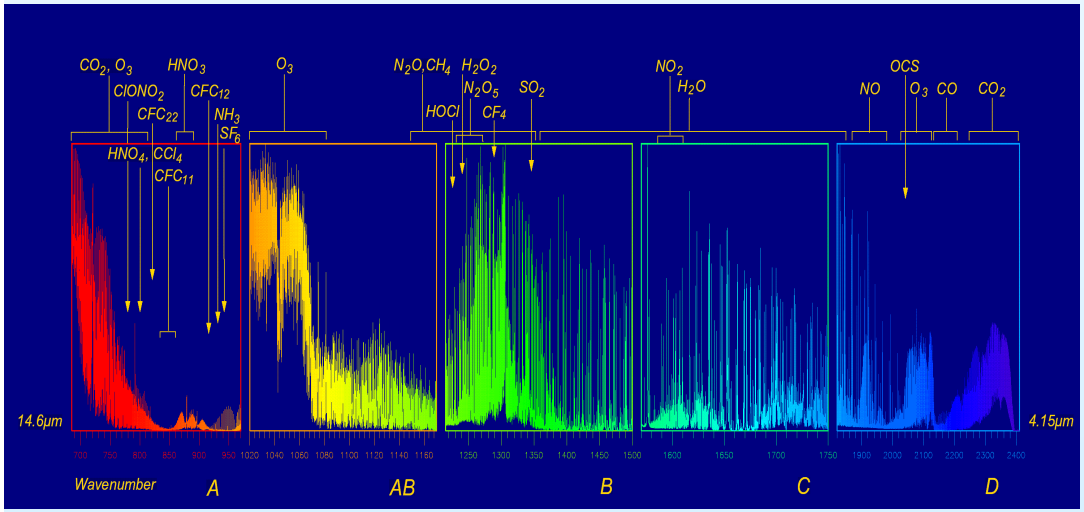
The MIPAS instrument

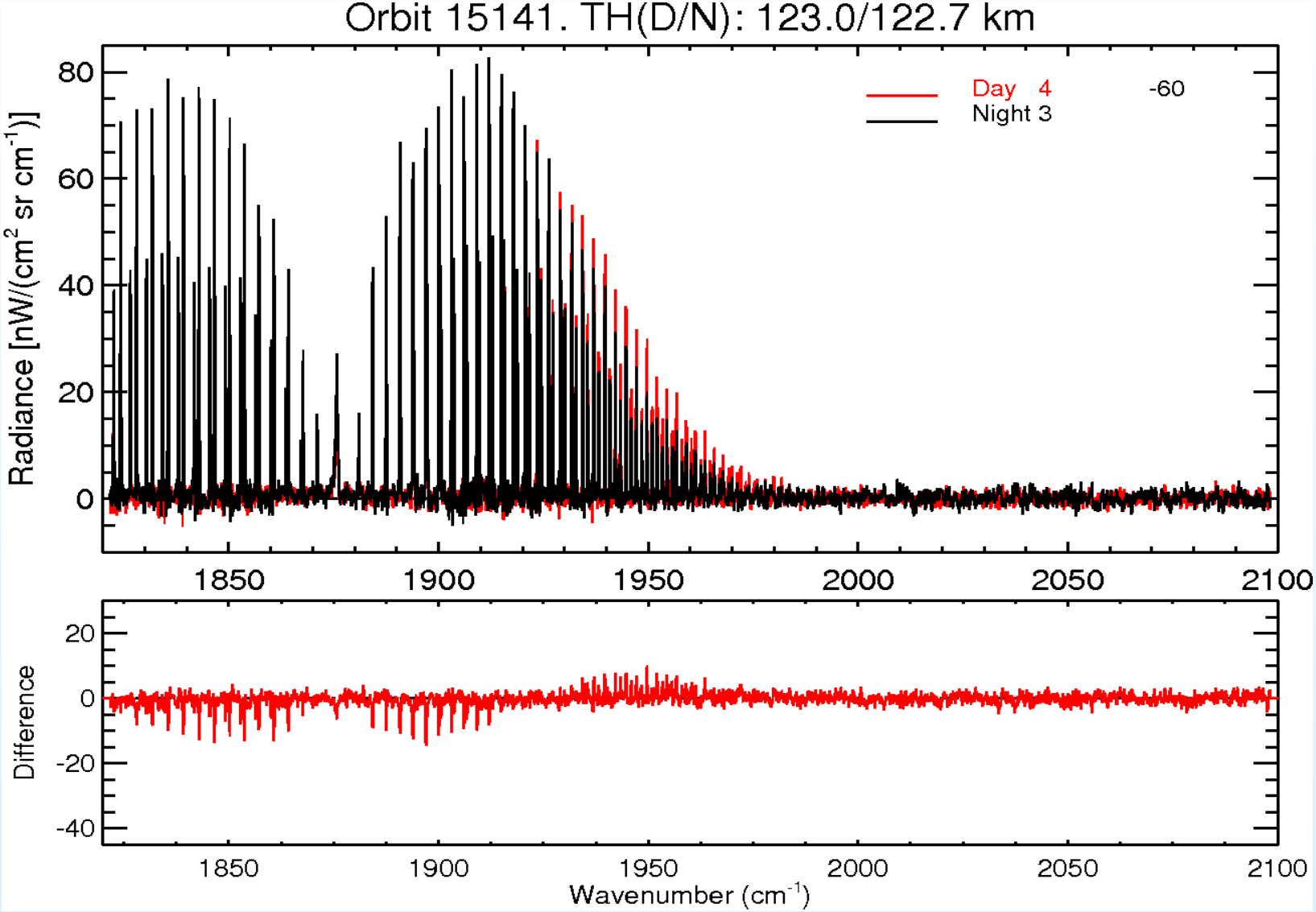




- IR limb emission Fourier spectrometer on ENVISAT
- Launched 1 March 2002 on sun-synchronous polar orbit, 98.5°.
- Measures day and night (polar!), global latitude coverage
- Spectra in 14.6-4.15μm (685-2410 cm^{-1}) at 0.035 (0.0625) cm^{-1}.
- Altitude range 6 to 70 km (up to 170km)
- 2002-2004: high spectral res., vertical resolution 3 - 6 km
- Since 2005: optimized spectral res. => better spatial resolution

NO emission at ~123 km

- **Rotational and spin lines resolved.**



MIPAS Reduced Resolution Modes

This table lists the scan sequences for MIPAS reduced-resolution operations since January 2005. Most of these are defined in Mission Plan V4.2 (July 05) although the "old" UTLS-1 mode was defined in the "Planning of MIPAS Special Modes - January 2005 Campaign" (Jan 05)

Mode:	Nominal	UTLS-1 (old)	UTLS-1 (new)	UTLS-2	MA	UA	NLC	AE
Horiz.Spacing	410km	275km	290km	180km	430km	375km	515km	n/a
Alt. Grid	Float	Float	Float	Fixed	Fixed	Fixed	Fixed	Fixed
Sweeps/Scan	27	18	19	11	29	35	25	12
Scan#1	70	49	49	42	102	172	102	38
Scan#2	66	44	44.5	37	99	167	99	33.5
Scan#3	62	39	40	33	96	162	96	29
Scan#4	58	34	35.5	29	93	157	93	24.5
Scan#5	54	31	31	26	90	152	90	20
Scan#6	50	28	28	23	87	147	87	17
Scan#7	46	26	25	20	84	142	85.5	15
Scan#8	43	24	23	18	81	137	84	13
Scan#9	40	22	21	16	78	132	82.5	11.5
Scan#10	37	20.5	19	14	75	127	81	10
Scan#11	34	19	17.5	12	72	122	79.5	8.5
Scan#12	31	17.5	16		69	117	78	7
Scan#13	29	16	14.5		66	112	75	
Scan#14	27	14.5	13		63	107	72	
Scan#15	25	13	11.5		60	102	69	
Scan#16	23	11.5	10		57	99	66	
Scan#17	21	10	8.5		54	96	63	
Scan#18	19.5	8.5	7		51	93	60	
Scan#19	18		5.5		48	90	57	
Scan#20	16.5				45	87	54	
Scan#21	15				42	84	51	
Scan#22	13.5				39	81	48	
Scan#23	12				36	78	45	
Scan#24	10.5				33	75	42	
Scan#25	9				30	72	39	
Scan#26	7.5				27	69		
Scan#27	6				24	66		
Scan#28					21	63		
Scan#29					18	60		
Scan#30						57		
Scan#31						54		
Scan#32						51		
Scan#33						48		
Scan#34						45		
Scan#35						42		

- UA mode (42-172 km):
  - @ 3 km steps
  - 102 to 172 km @ 5-km

UA: Temperature and NO retrieval setup

- Retrieval setup:
  - Use of "Micro-windows"
    - Fundamental band lines of NO(1-0).
  - Regularization.
  - Previous TLOS retrieval up to 100 km (CO2 15μm).
  - Non-LTE model accounting for vibrational, rotational and spin non-LTE.
  - Atomic oxygen from MSIS.

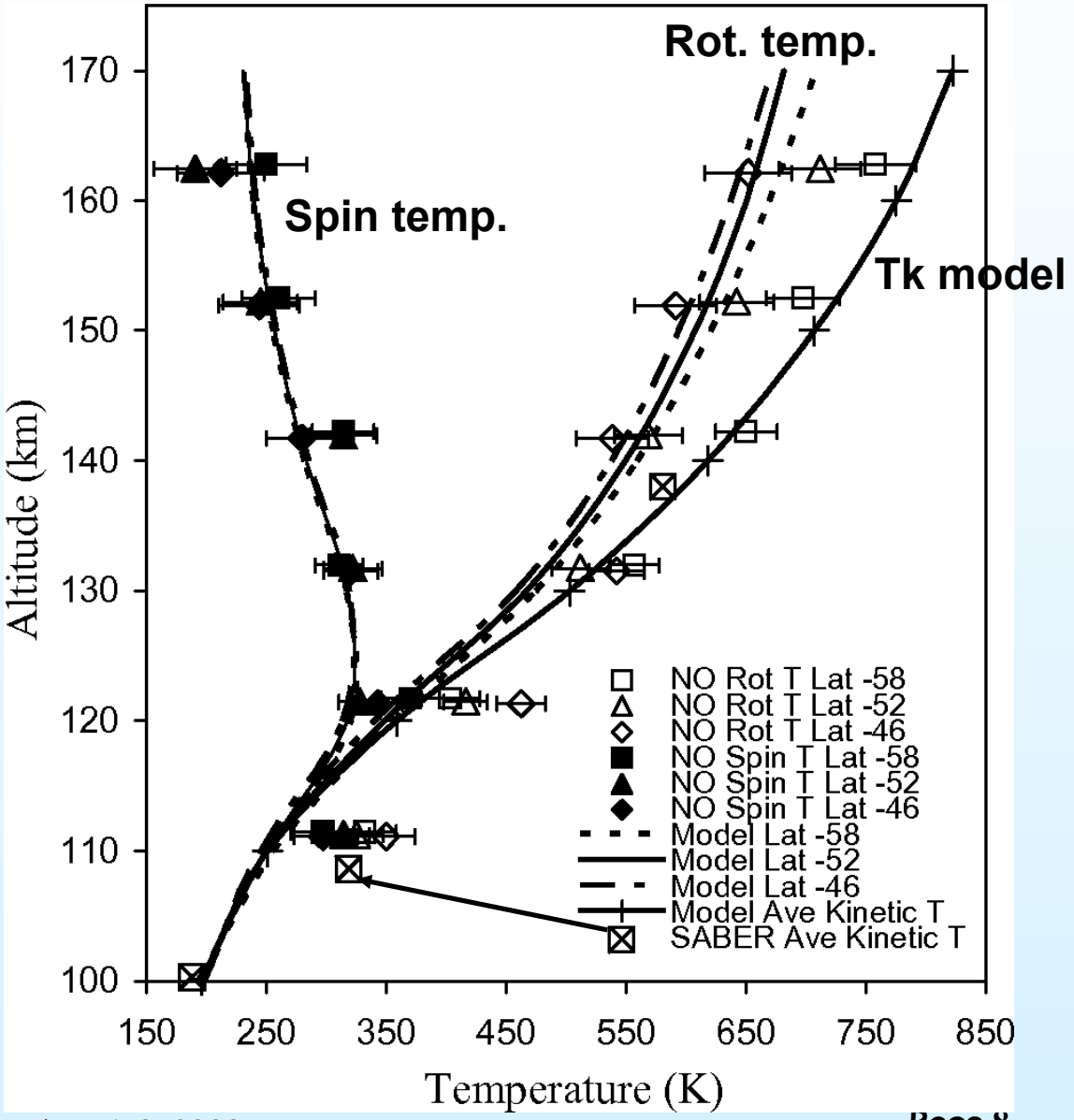
Temperature and NO retrieval setups

	Temperature 15 µm	Temperature Rot. 5.3 µm	NO vmr 1st step	NO vmr 2nd step
Tangent heights	40-100 km	90-170 km	90-170 km	40-90 km
Microwindows	685-793 cm^{-1}	1840-1940 cm^{-1}	1840 -1940 cm^{-1}	1840 -1940 cm^{-1}
Non-LTE	Vibrational	Vibrational, rotational, spin	Vibrational, rotational, spin	Vibrational, rotational, spin
Retrieval grid	40-120 km	90-200	90-200	40-100
Regularisation		Tikhonov 1st order	Tikhonov 1st order	Tikhonov 1st order

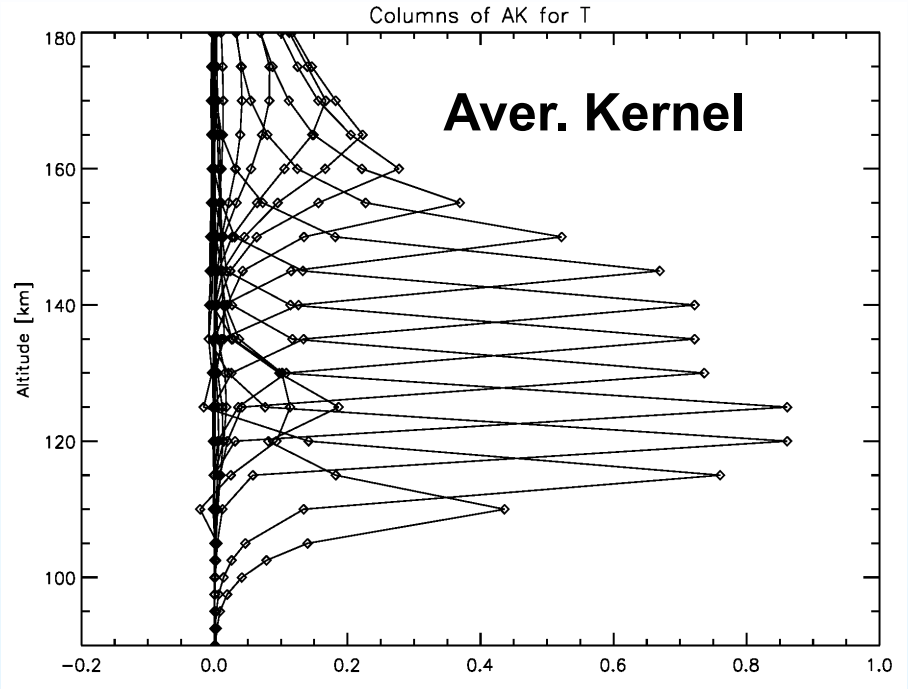
NO non-LTE spin and rot. temperatures

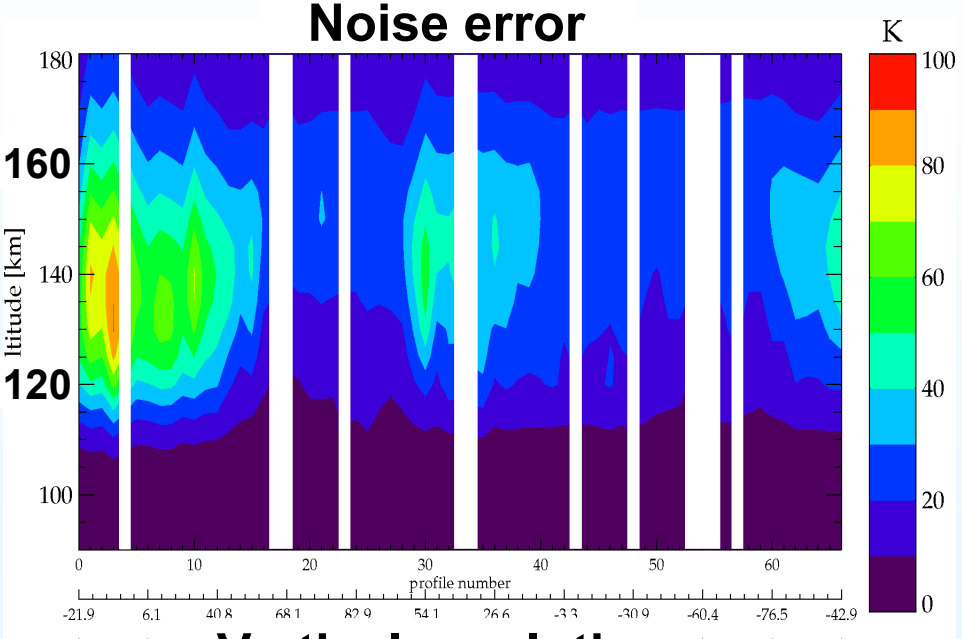
- MIPAS non-LTE spin and rotational temperatures
- Good agreement with non-LTE model predictions

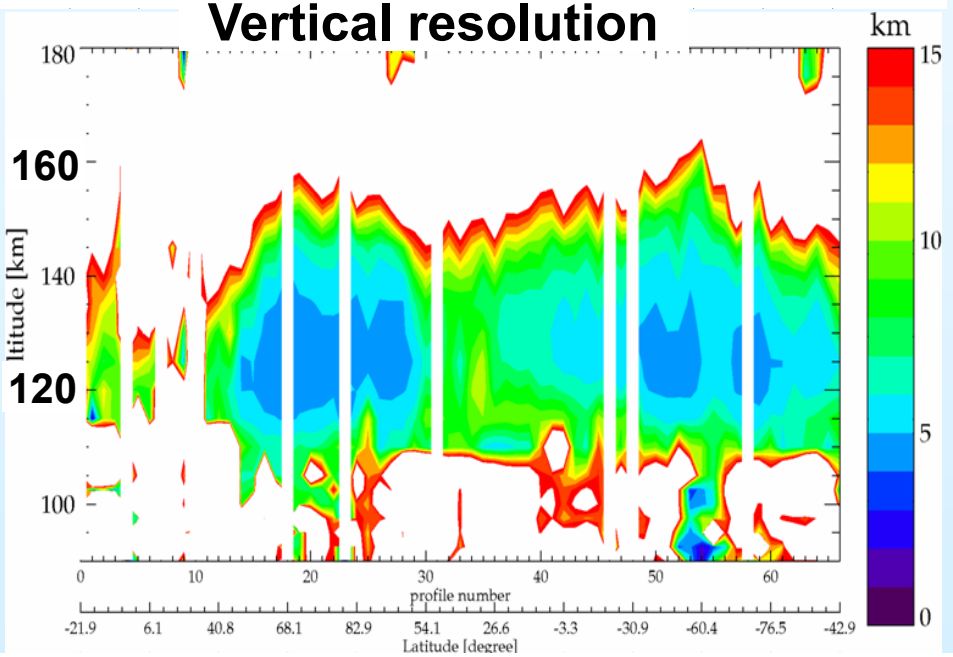
- Gardner, Funke, López-Puertas et al., JGR, 2007.



Performance of Temp retrieval (22 Dec 06, Ap moderate)



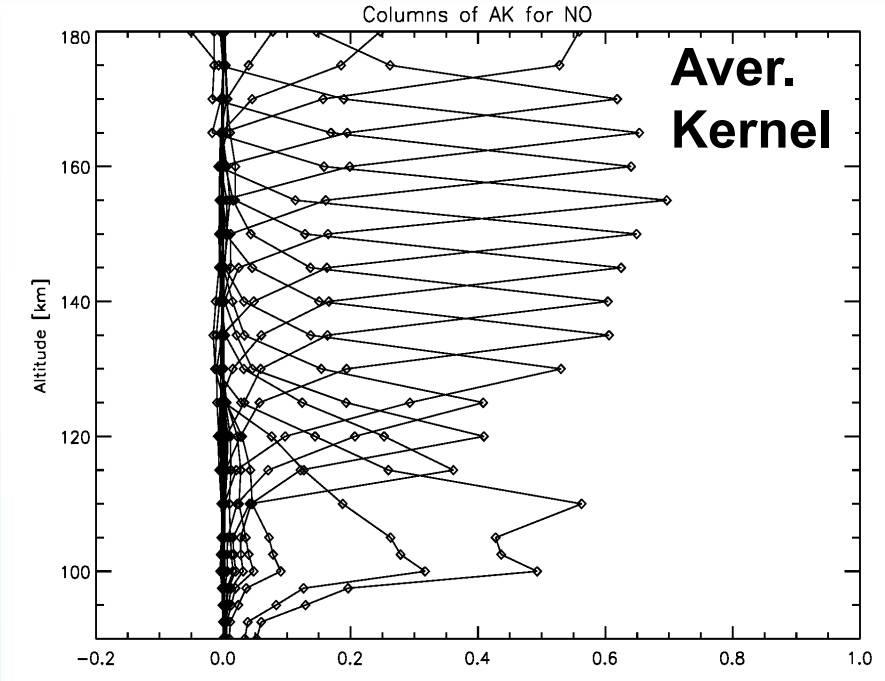


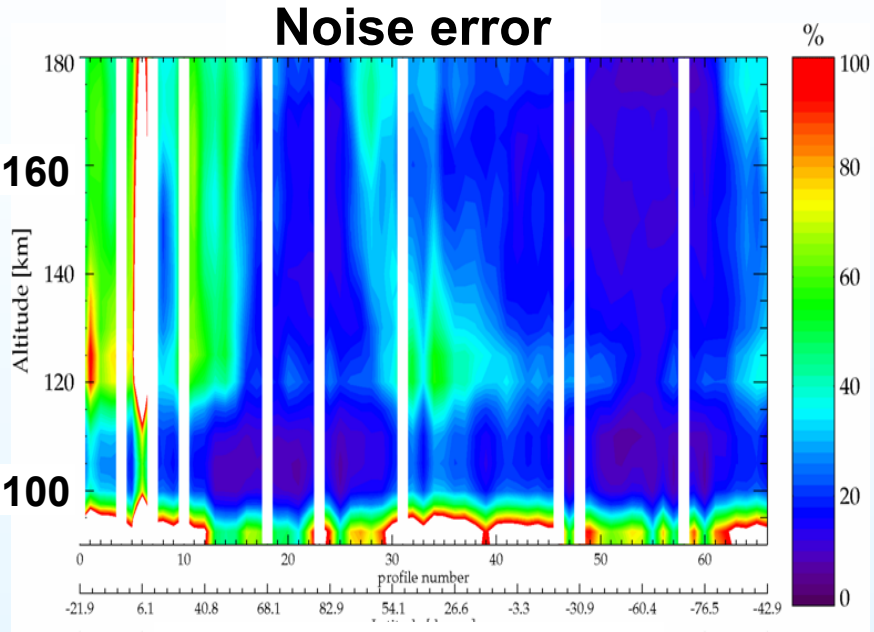


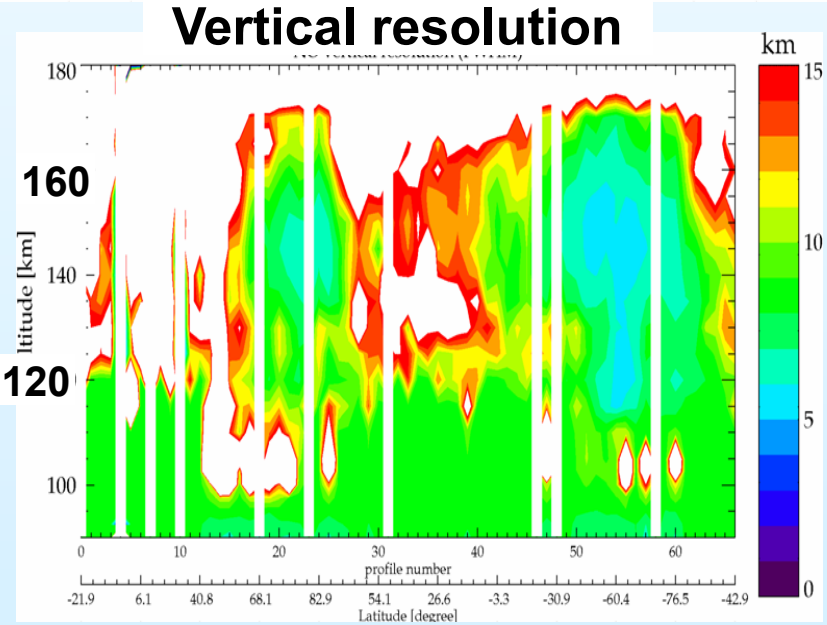
Orbit 25150:

- Noise error: 5-30 K
- Vertical resolution: 5-10 km
- Convergence: 85%

NO vmr retrieval performance (22 Dec 06, Ap moderate)





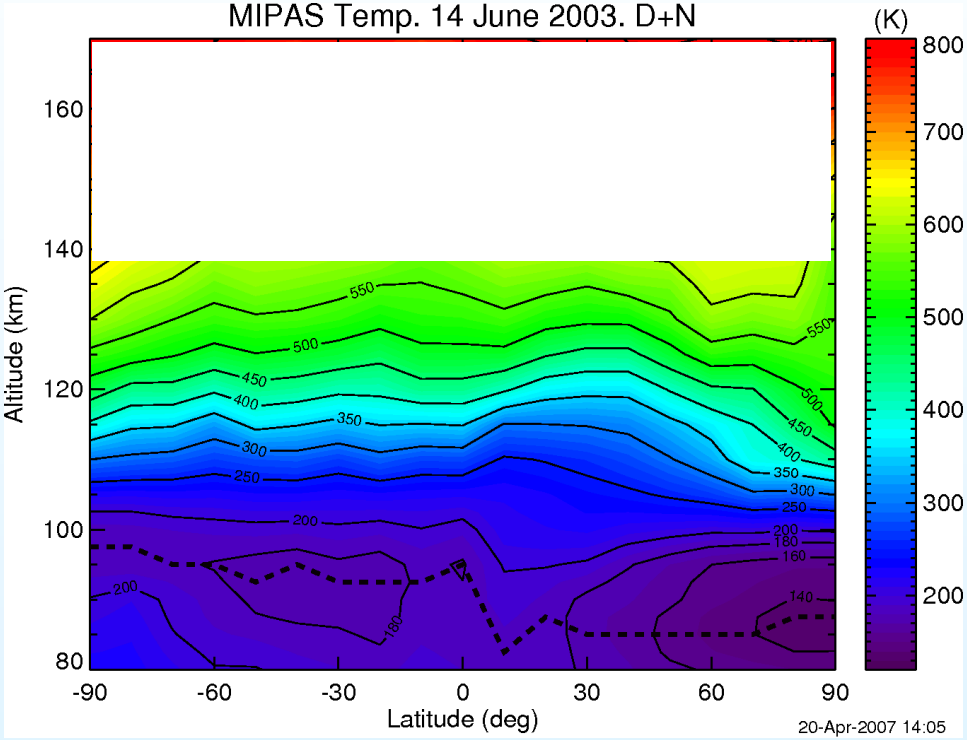


- Noise error: 5-20 %
- Vertical resolution: 5-10 km
- Convergence: 85%

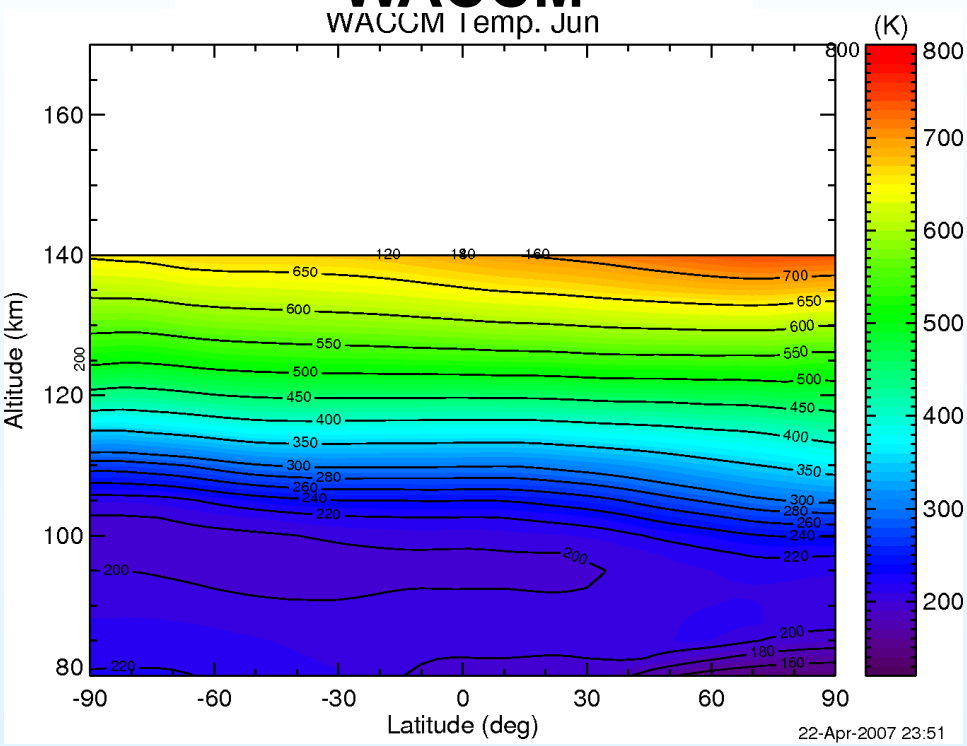
14 June 2003. Moderate Ap

Temp. Comparison with WACCM. June 03

MIPAS

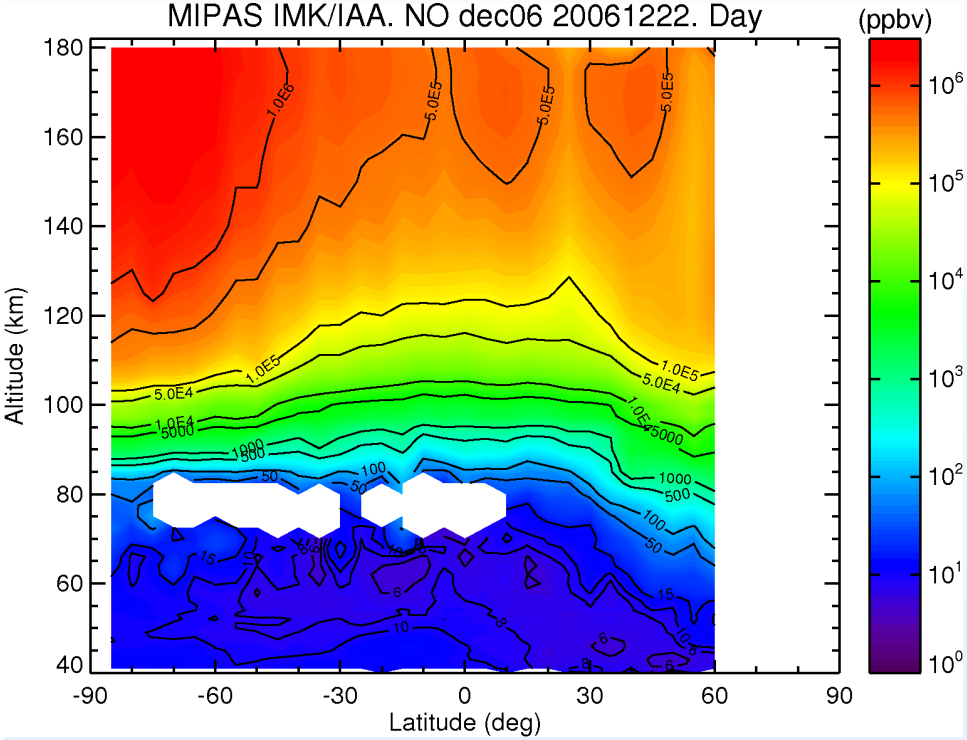


WACCM

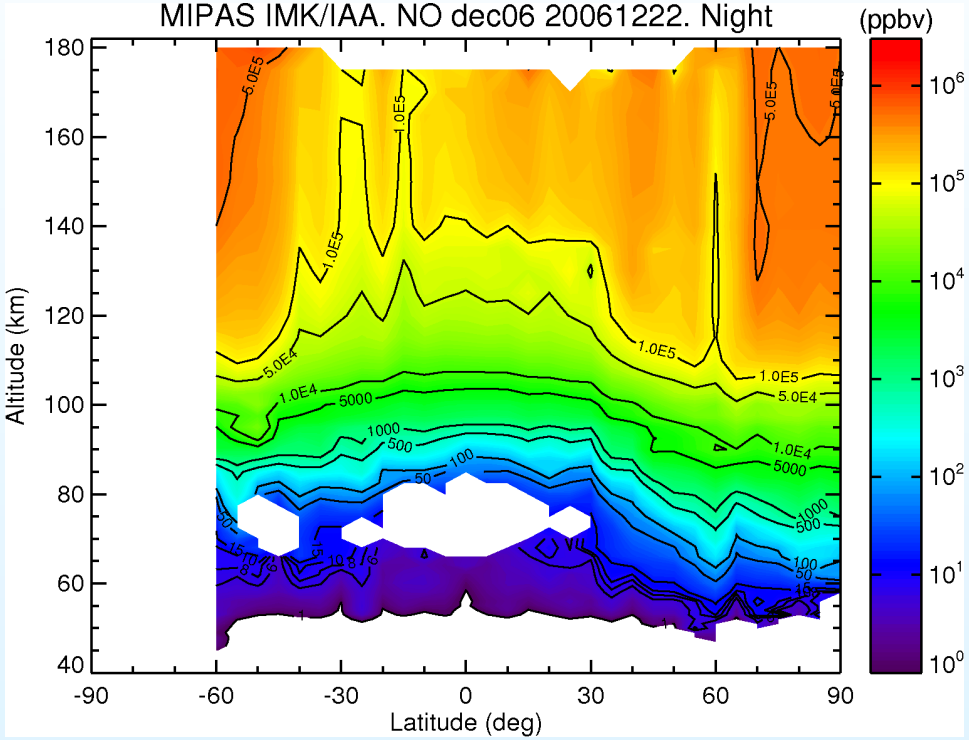


NO vmr. 22 Dec 2006

Day

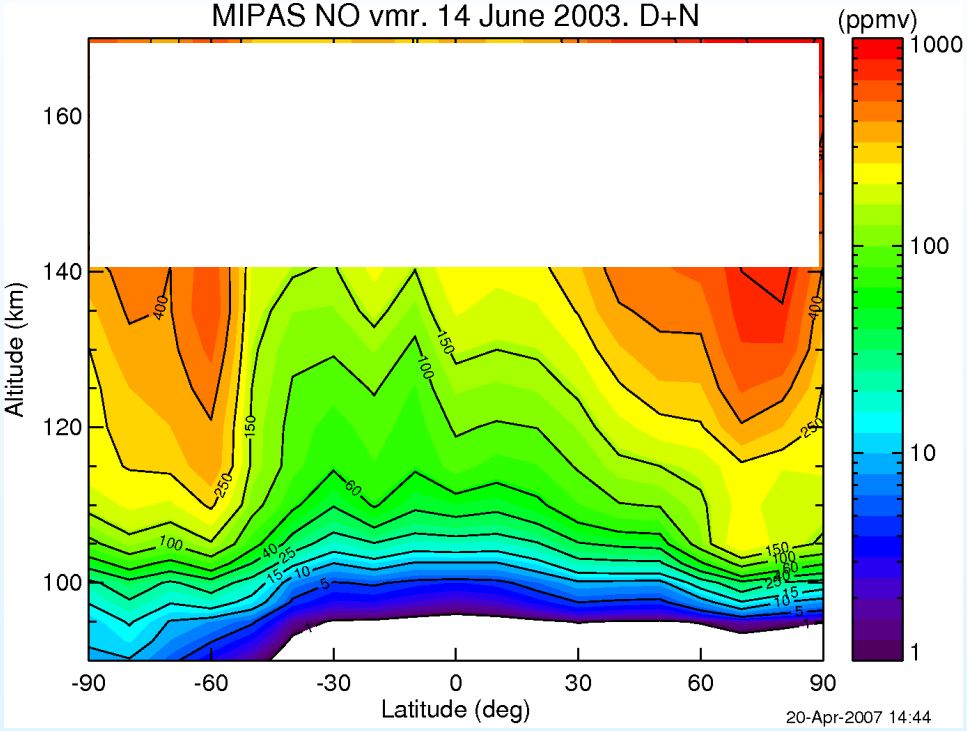


Night

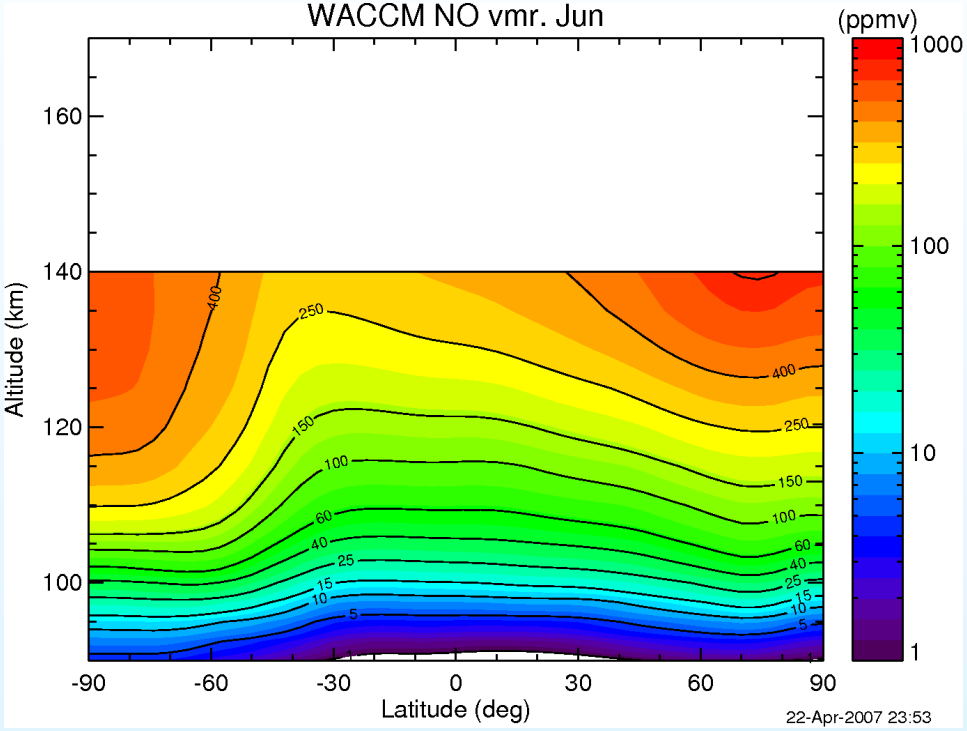


NO vmr. Comparison with WACCM. June 03

MIPAS

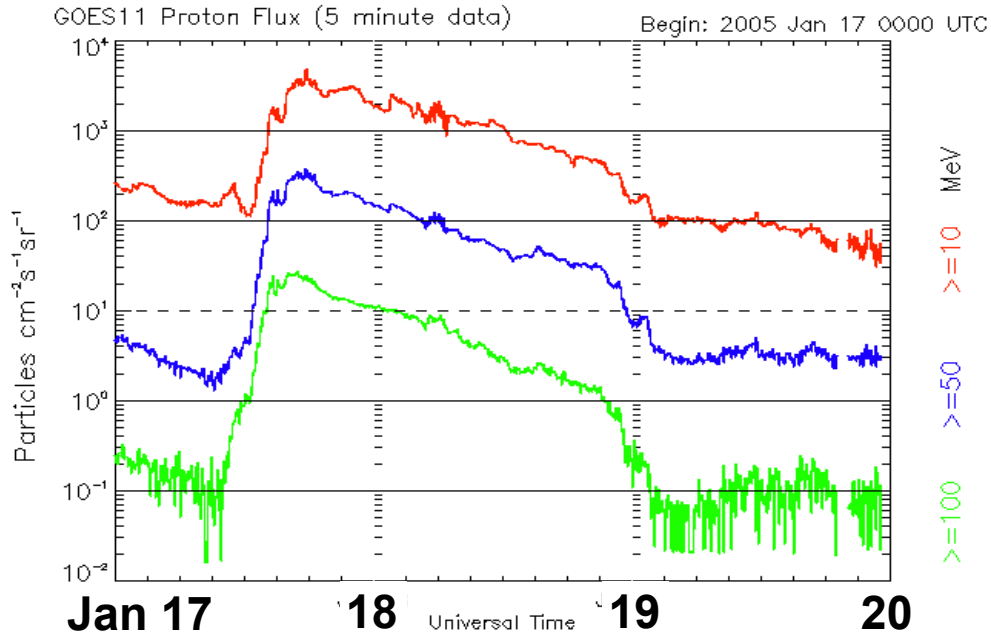


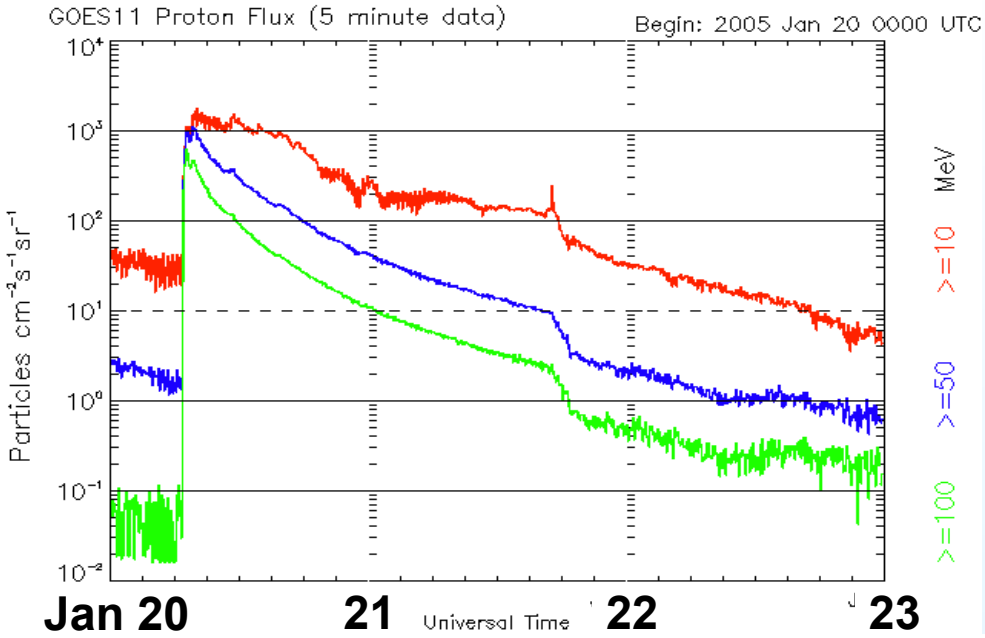
WACCM

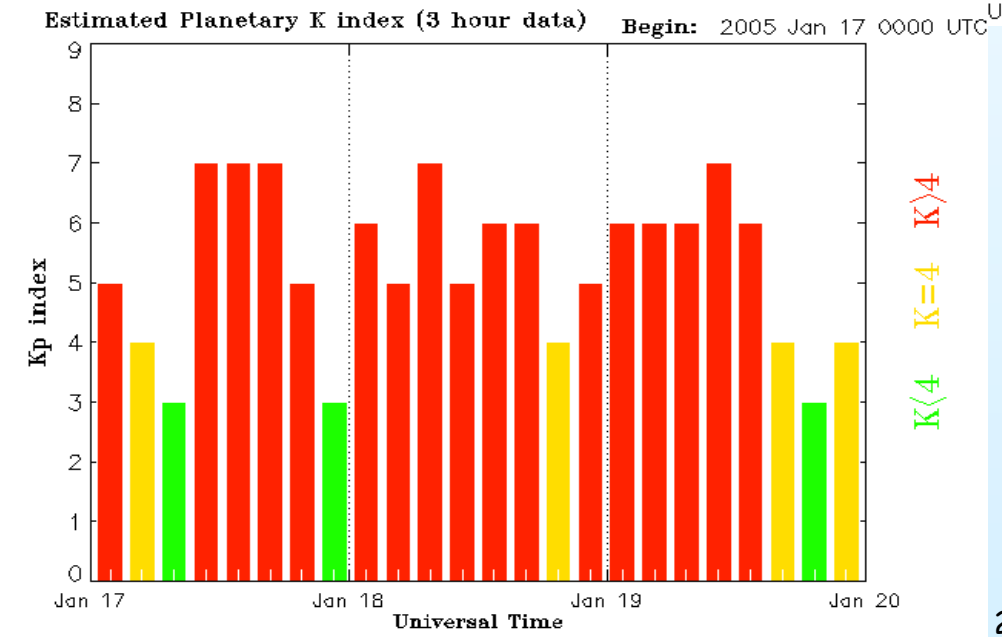


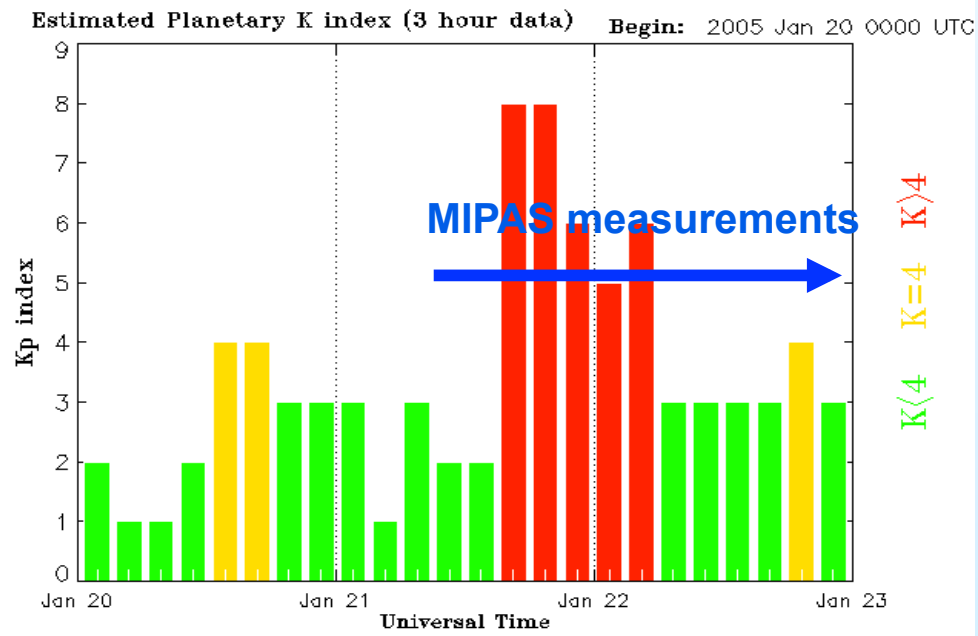
Solar Storm Jan 2005: Temp. & NO

Solar Storm Jan 2005: Proton fluxes. Kp index





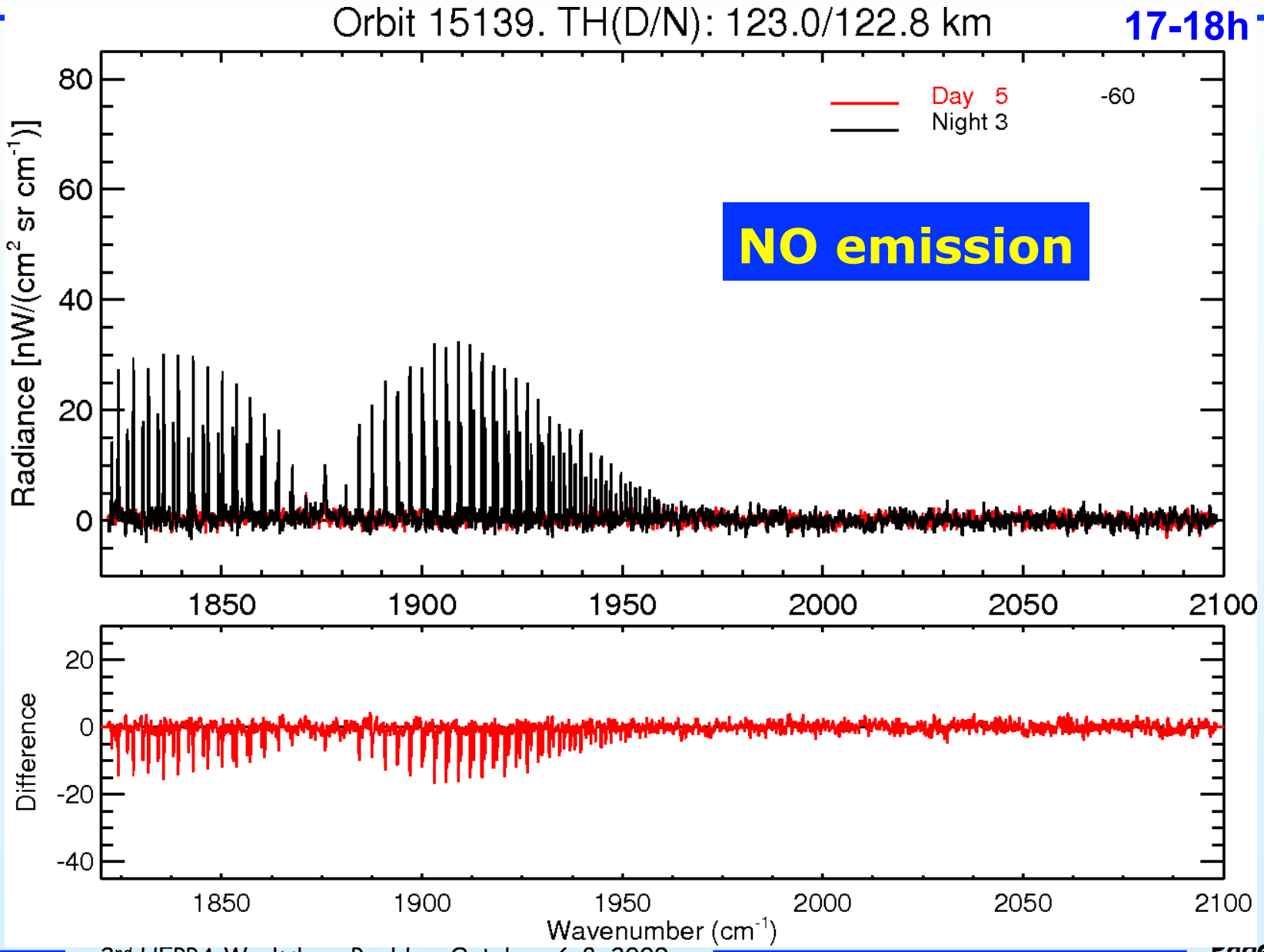




Solar Storm 21 Jan 2005

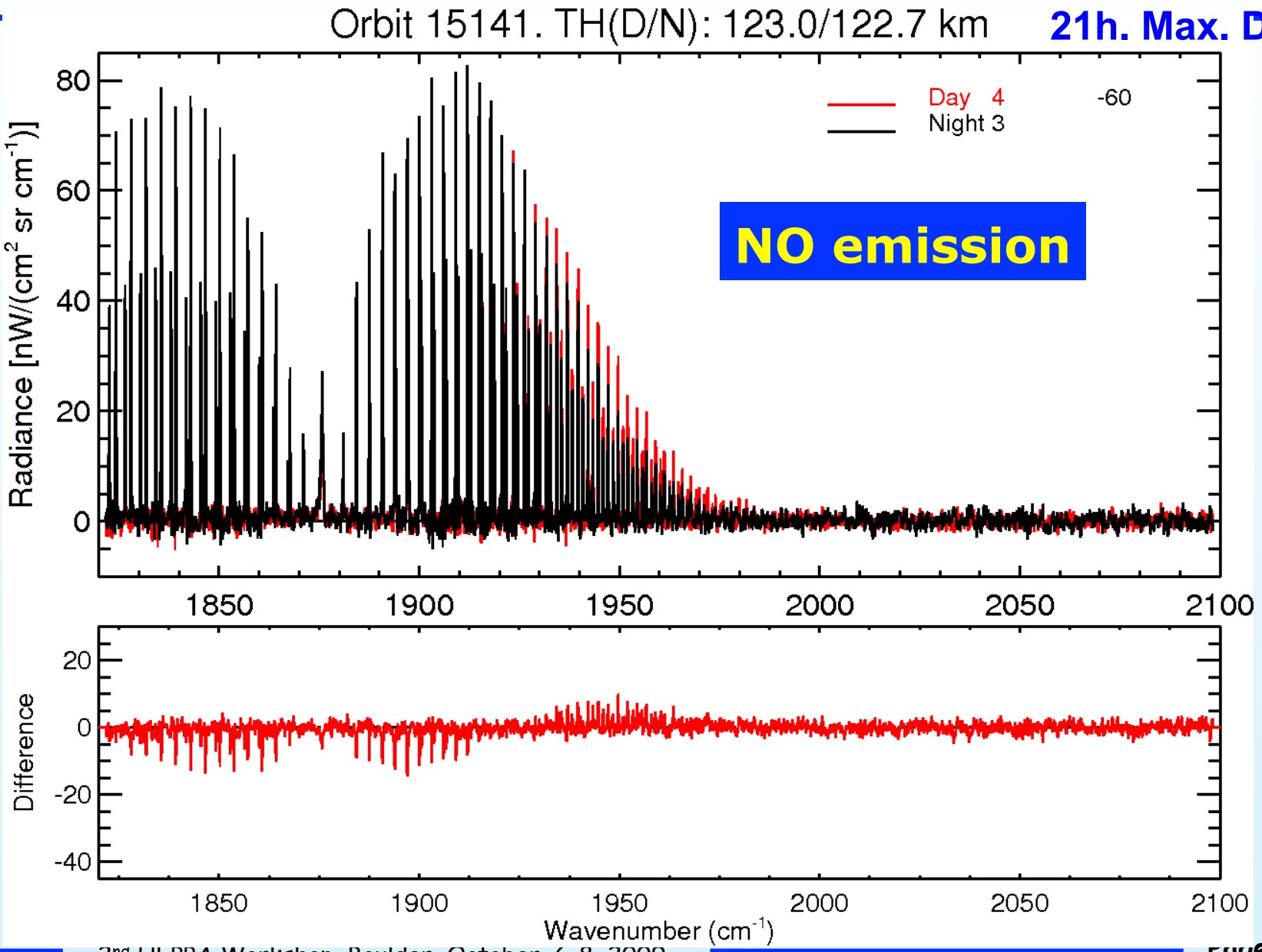
70°S-50°S

17-18h



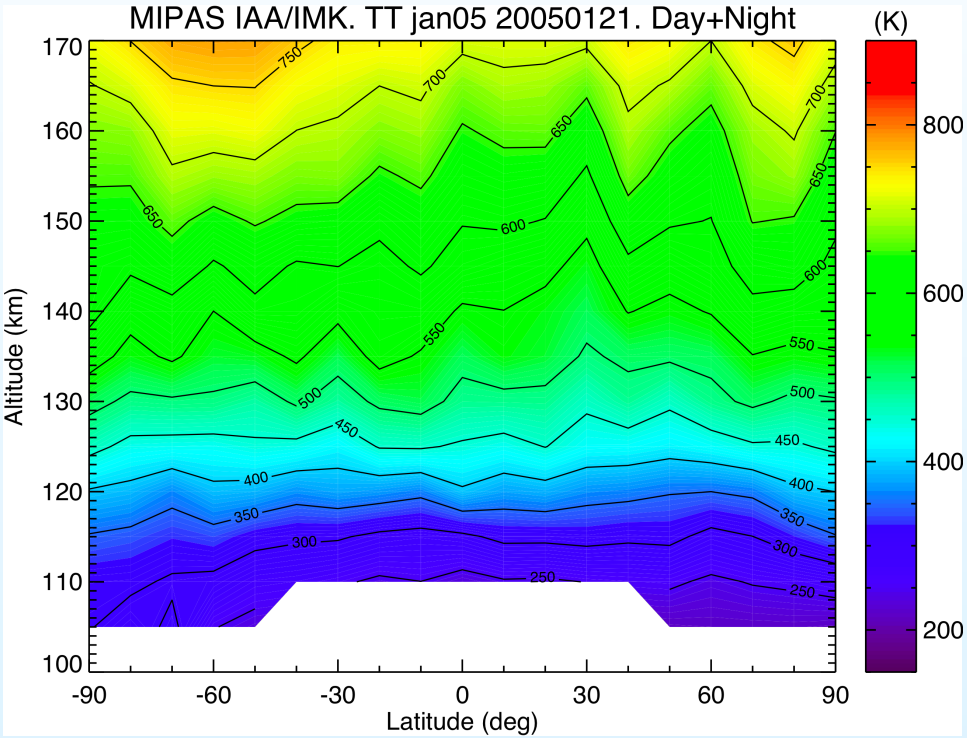
Solar Storm 21 Jan 2005

70°S-50°S

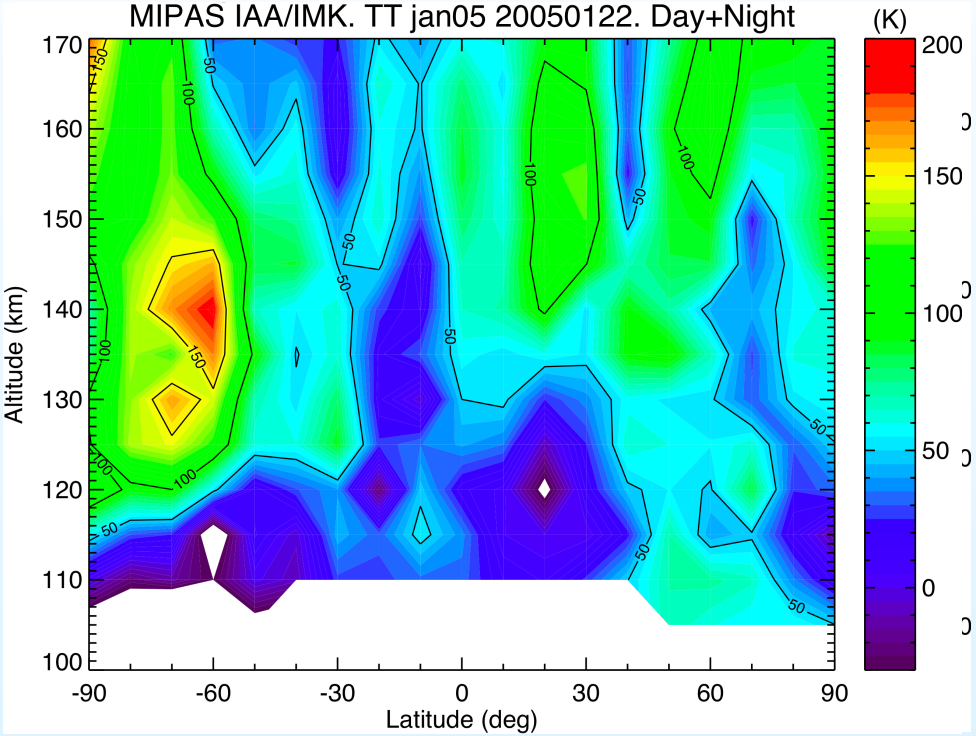


Temp. change during SPE

Pre-SPE

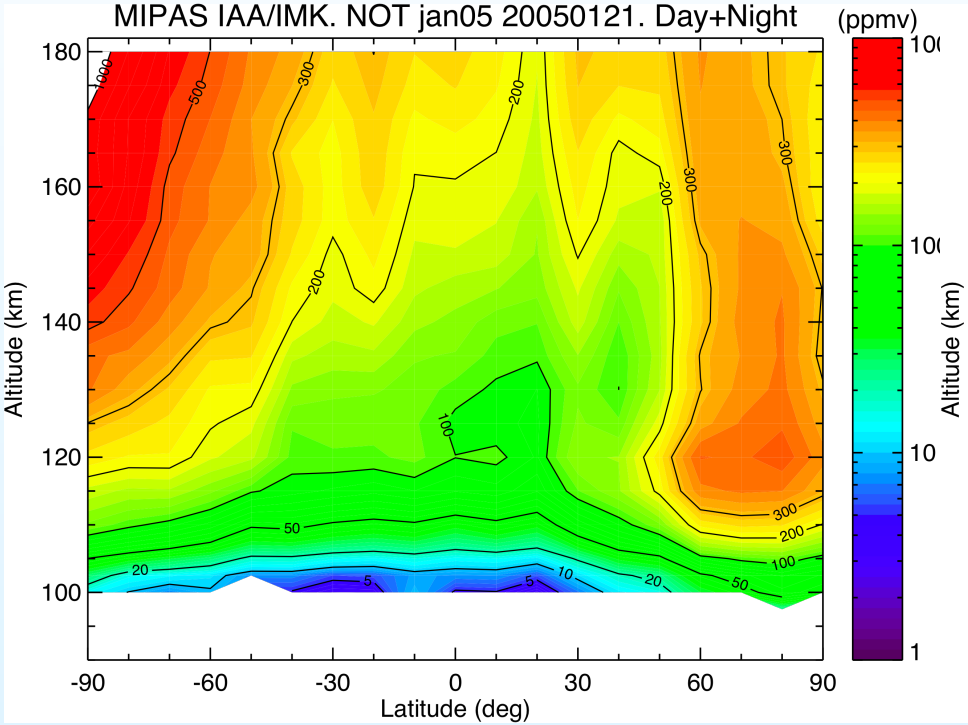


Diff.

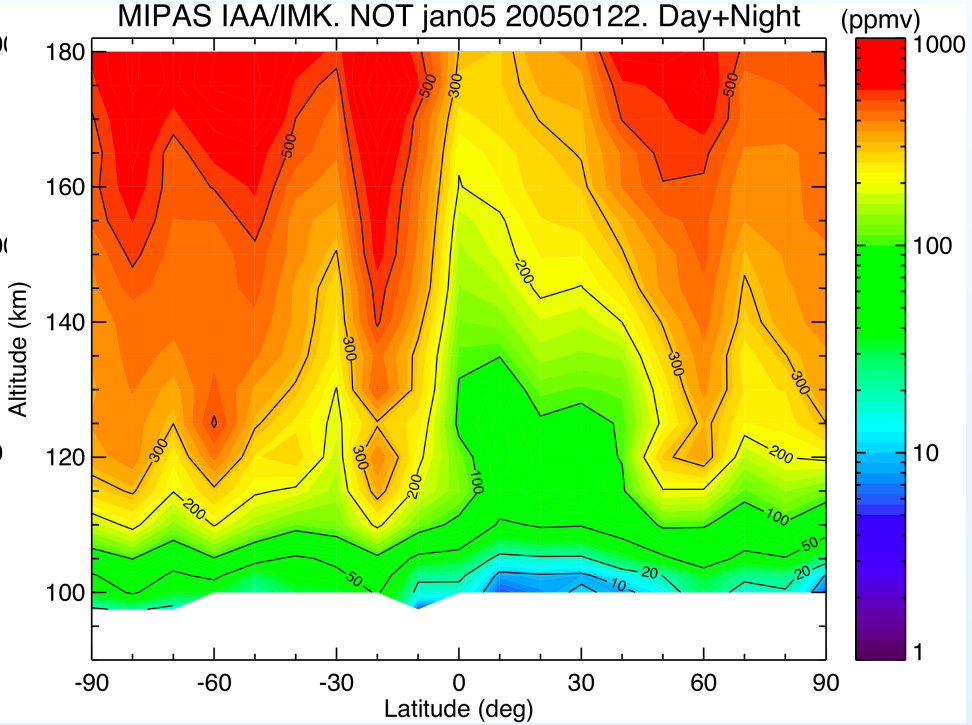


NO change during SPE

Pre-SPE

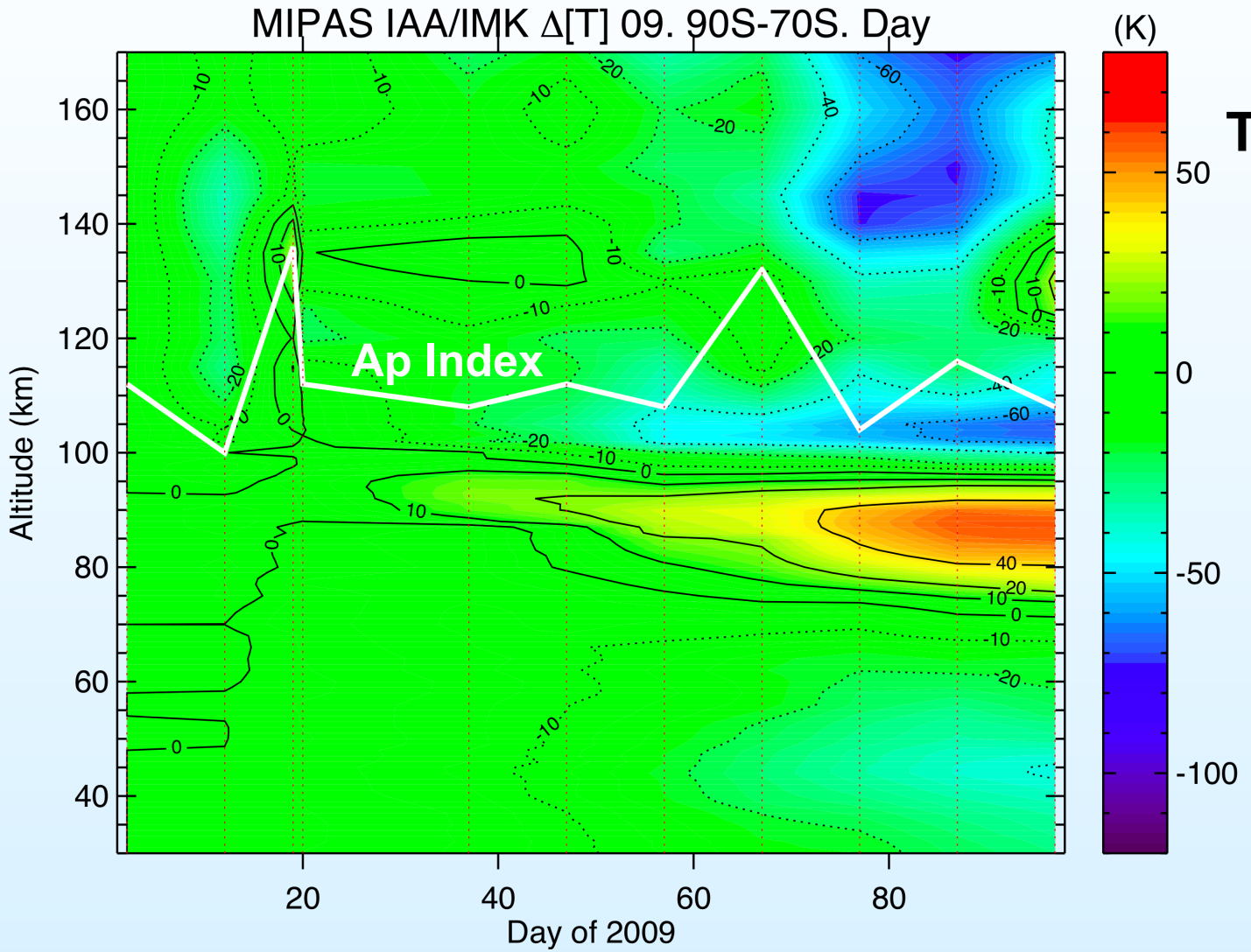


SPE



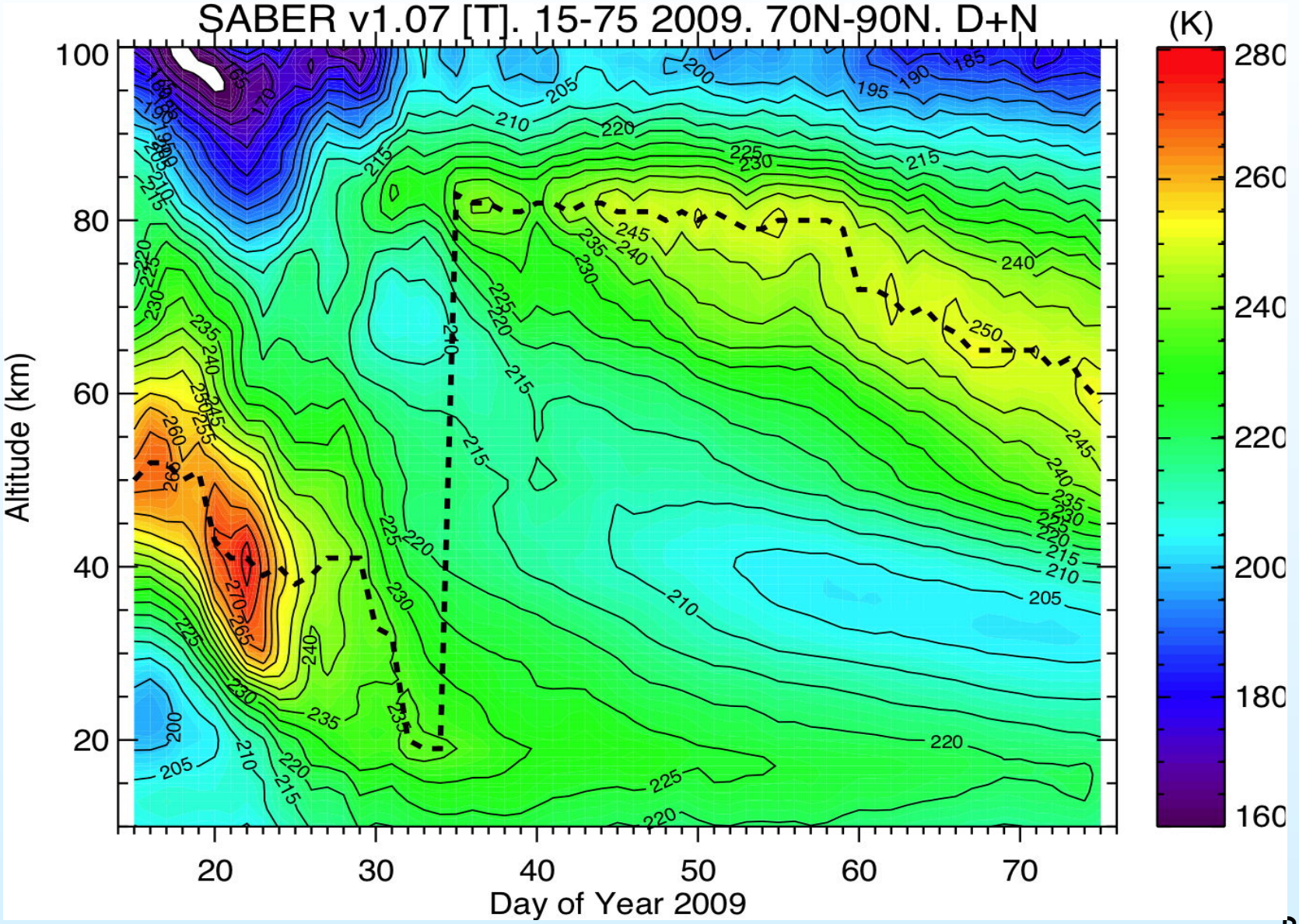
Jan-Mar 2009:
SH: Summer-Winter transition
NH: Strat-warm

Temp. Jan-Apr 2009. SH

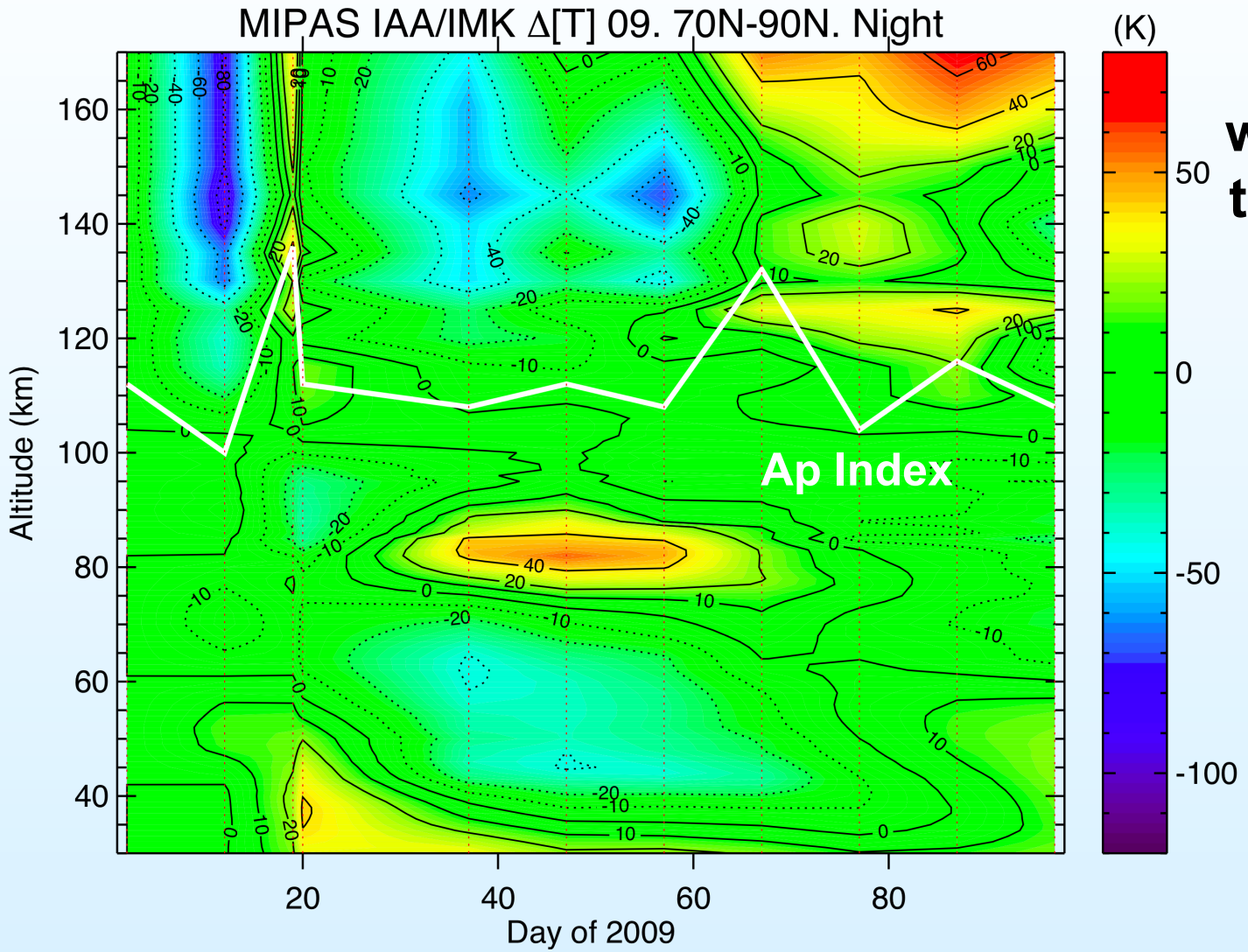


Mesosphere/ Thermosphere coupling

SABER Temp. NH Winter 2009

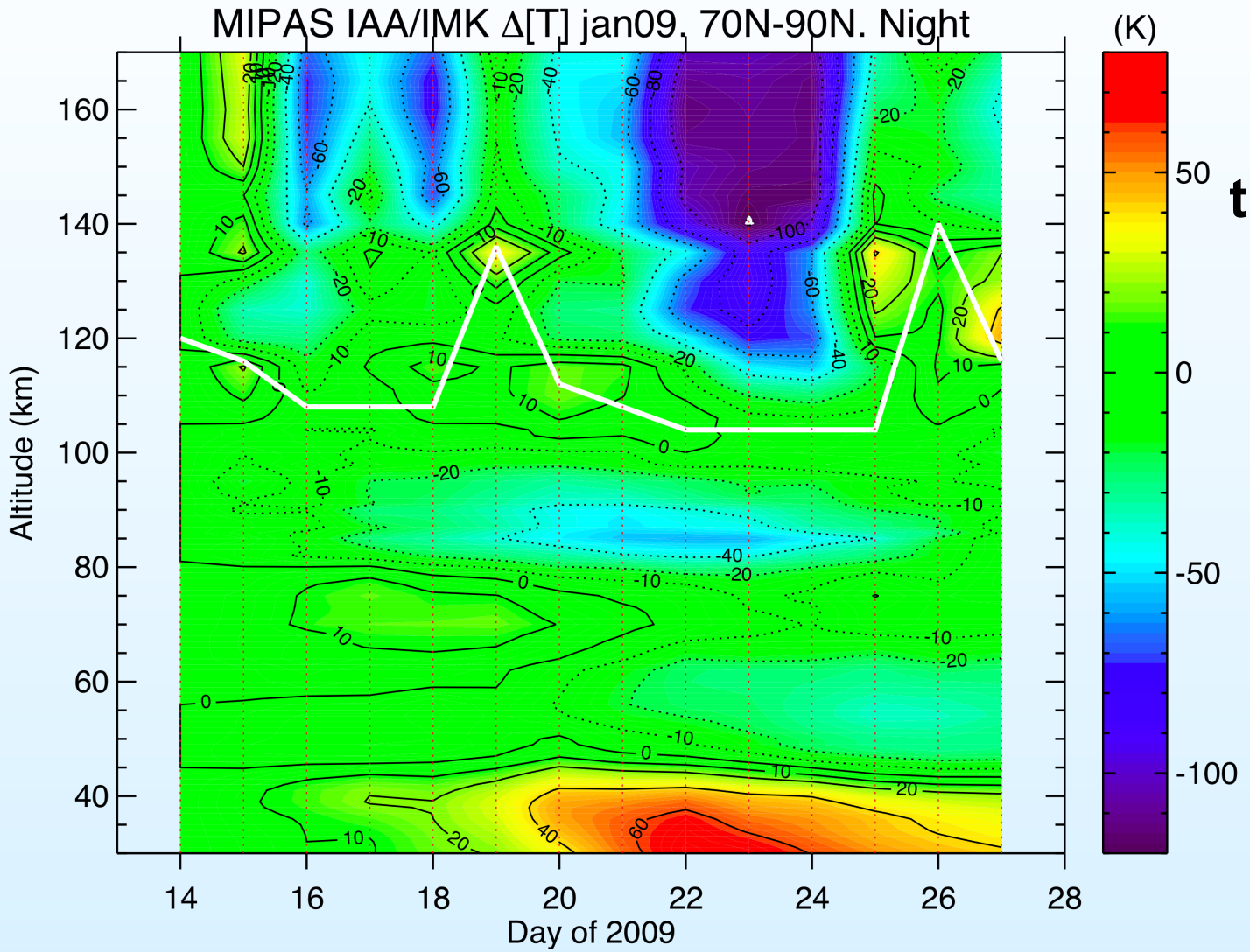


Temp. Jan-Apr 2009. NH



Post-Strat-warm effects in thermosphere?

Temp. Jan 2009. NH



Strat-warm effects in thermosphere?

Summary/Conclusions

- A retrieval scheme for thermospheric NO and Tk from MIPAS spectra at 5.3 μm has been developed.
- MIPAS provides global lat. coverage, Day & Night for Tk and NO in the thermosphere (105-170 km), 1/10 days.
- Temperature: Noise error: 5-30 K; Vertical res.: 5-10 km
- Nitric Oxide: Noise error: 5-20%; Vertical res: 5-10 km
- SPE Jan 2005 increase Tk in 150 K and NO in 400 ppmv
- Apparent Mesosphere/Thermosphere coupling observed
- Strat-warm effects possibly seen in the thermosphere?

Thank you!