



Supplement of

Solar FTIR measurements of NO_x vertical distributions – Part 1: First observational evidence of a seasonal variation in the diurnal increasing rates of stratospheric NO_2 and NO

Pinchas Nürnberg et al.

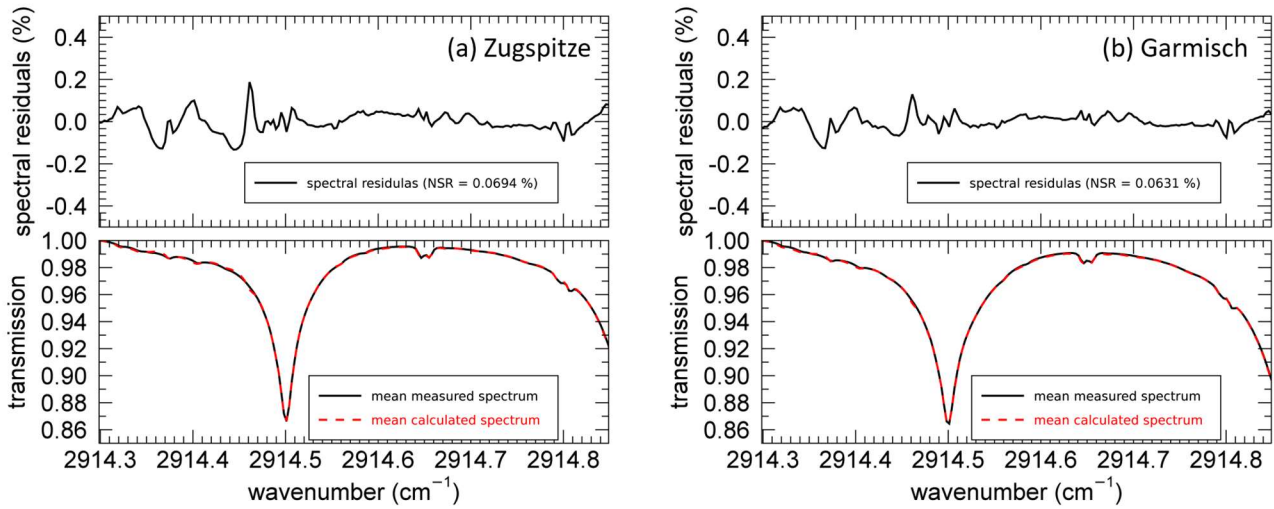
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S1 Retrieval

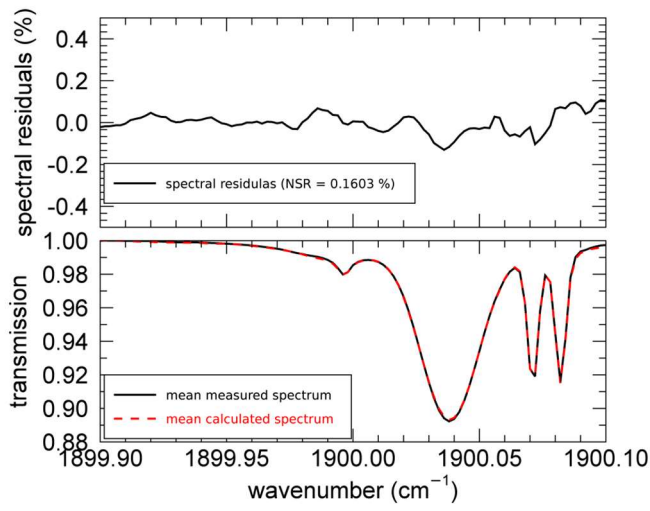
Table S1. NO₂ and NO retrieval parameters including interfering species, a priori profiles and line lists used for retrieval with PROFFIT96 v2022 code.

	NO ₂ (Garmisch)	NO ₂ (Zugspitze)	NO (Zugspitze)
spectral micro window	2914.30 – 2914.85 cm ⁻¹		1899.90 – 1900.10 cm ⁻¹
species retrieved via vmr profile inversion	NO ₂ (mean DOFS = 1.48), CH ₄ (mean DOFS = 2.78)	NO ₂ (mean DOFS = 1.38), CH ₄ (mean DOFS = 2.68)	NO (mean DOFS = 2.14), CO ₂ (mean DOFS = 1.48)
species retrieved via vmr profile scaling	H ₂ O, O ₃ , H ₂ CO, OCS, C ₂ H ₆		O ₃
species included in the forward calculation (not retrieved)	-		H ₂ O, N ₂ O
spectroscopy	ATMOS version 20200512		HITRAN version 2020
vertical profile resolution	47 levels (0.745 km to 120 km)	43 levels (2.964 km to 120 km)	
a priori profile NO ₂ / NO	WACCM V6		
a priori profile CH ₄ / CO ₂	gfit daily		
a priori profile other interfering species	gfit daily		
T,p profiles	National Centers for Environmental Prediction (NCEP)		
NO ₂ / NO regularization	Tikhonov L ₁		
CH ₄ / CO ₂ regularization	Tikhonov L ₁		
fit of solar spectrum	yes		



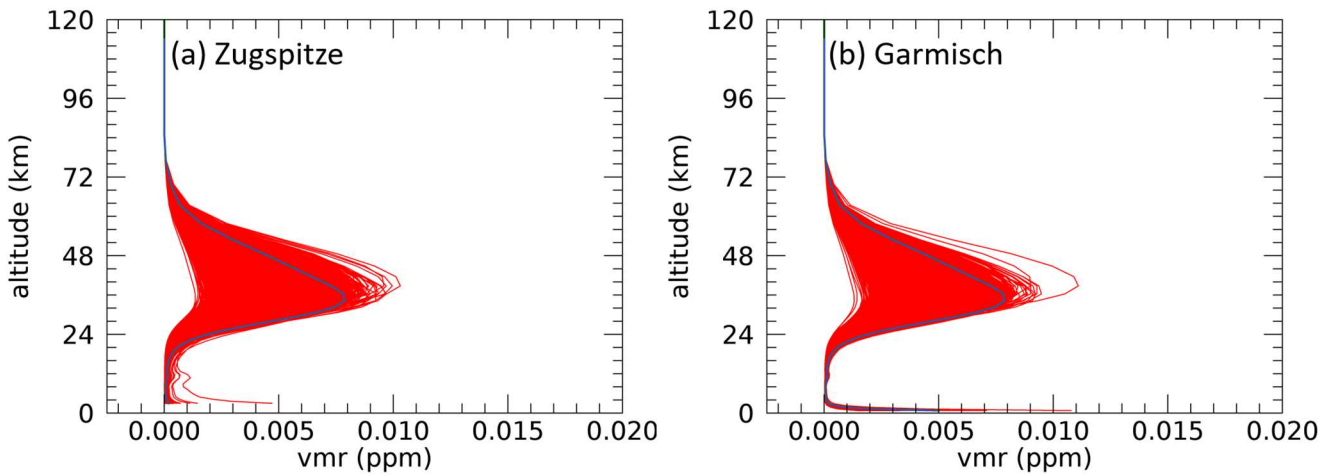
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Figure S1. Top row: resulting mean spectral residuals in dependency of the wavenumber of the retrieval of NO₂ at Zugspitze (a) and Garmisch (b). Additionally, the noise-to-signal ratio (NSR) of the mean spectral residuals is given in the legend. Bottom row: mean measured (black lines) and calculated (red lines) spectra in dependency of the wavenumber in the given micro-window of the retrieval of NO₂ at Zugspitze (a) and Garmisch (b).



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Figure S2. Top row: resulting mean spectral residuals in dependency of the wavenumber of the retrieval of NO at Zugspitze. the noise-to-signal ratio (NSR) of the mean spectral residuals is given in the legend. Bottom row: mean measured (black lines) and calculated (red lines) spectra in dependency of the wavenumber in the given micro-window of the retrieval of NO.



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Figure S3. Retrieved NO₂ vmr profiles from a) 1995 to 2022 above Zugspitze and b) 2004 to 2022 above Garmisch (after quality control; red lines). Additionally, the a priori profile (blue line) is shown.

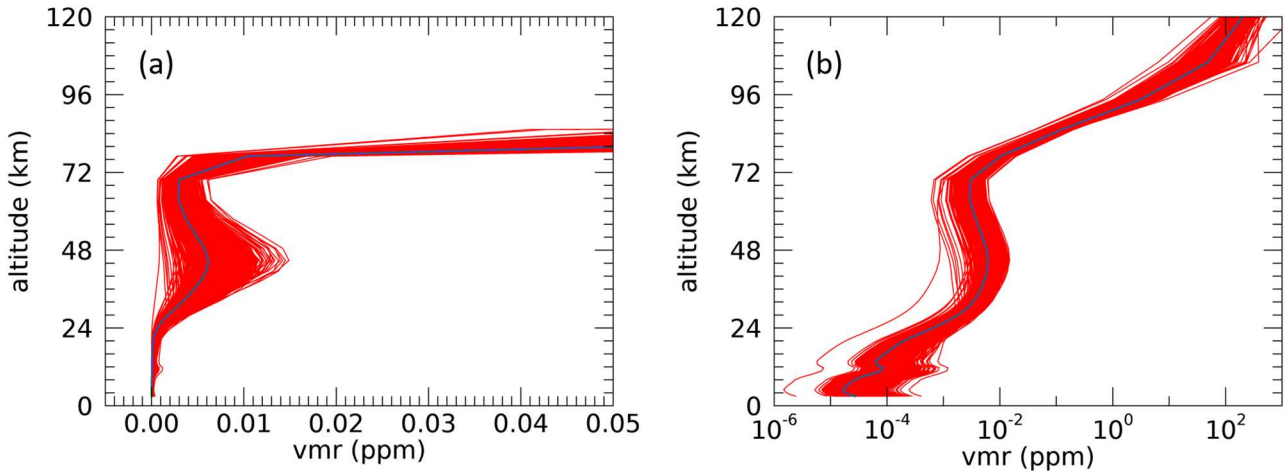


Figure S4. All retrieved NO profile families from 1995 to 2022 at Zugspitze as vmr profile against altitude after the quality control (red lines, see text for details). Additionally, the used a priori profile (blue line) is shown; a) linear x-axis, b) logarithmic x-axis.

S2 NO_x columns and pollution correction

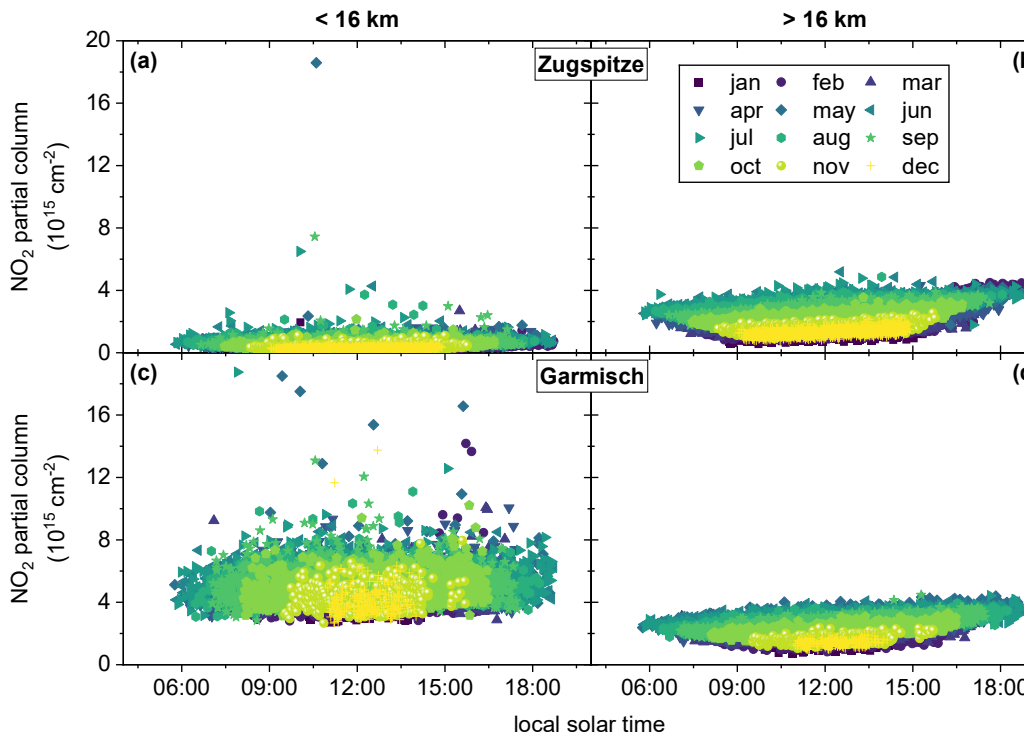
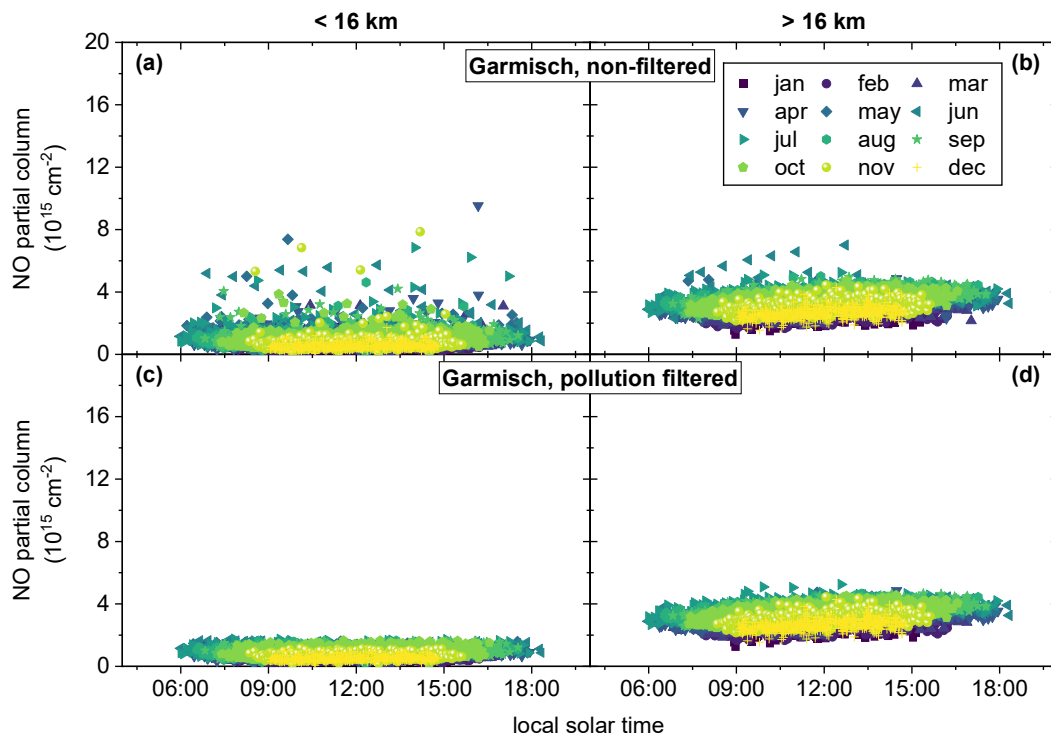
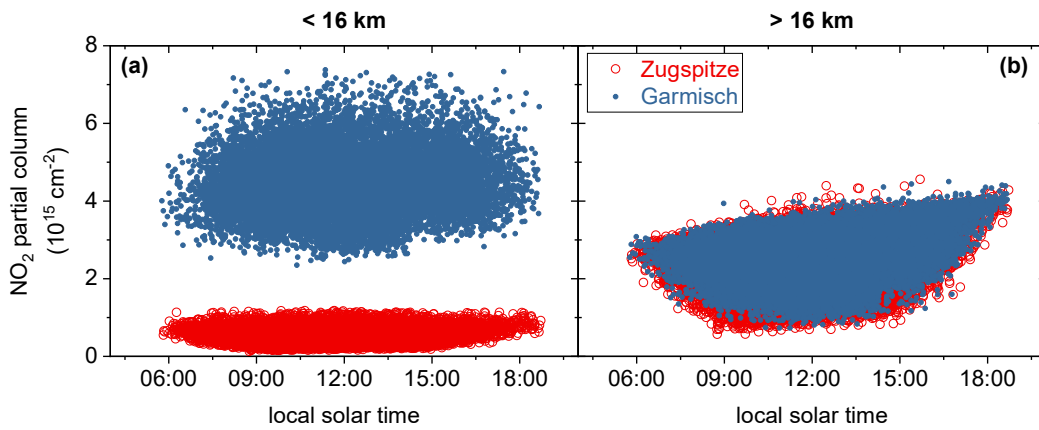


Figure S5. Retrieved NO₂ partial columns for every month below (left) and above (right) 16 km altitude above Zugspitze (top row) and Garmisch (bottom row) in dependency of local solar time (blue to yellow symbols from January to December, see legend).



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Figure S6. Retrieved Garmisch NO partial columns (top row) and pollution corrected NO partial columns (bottom row, see text for details) for every month below (left) and above (right) 16 km altitude in dependency of the local solar time (blue to yellow symbols from January to December, see legend).



30 **Figure S7.** Retrieved pollution filtered NO₂ partial columns below (a) and above (b) 16 km altitude measured at Zugspitze (red open symbols) and at Garmisch (blue filled symbols) in dependency of the local solar time.