Impact of Spectroscopic Line Data on Carbon Monoxide Column Density Retrievals from SWIR Nadir Observations

Denise Schmidt[1,2], Sebastián Gimeno García[1], Franz Schreier[1]

(1) DLR — Remote Sensing Technology Institute, Oberpfaffenhofen, GERMANY
(2) TUM — Technical University of Munich, Munich, GERMANY

Introduction

- SWIR spectra contain information about greenhouse gases (CO_2, CH_4, H_2O) and gases with indirect radiative forcing such as CO
- Down-looking SWIR spectra sensitive to the troposphere
  $\Rightarrow$ SWIR region especially suitable to sources and sinks analysis
- SCIAMACHY channels in the SWIR region:
  — Channel 8 mainly used for CO retrievals
  — Channel 6 exploited by most CH_4 and CO_2 retrievals
- Various auxiliary data required for Level 1$\rightarrow$2 processing

? How do molecular spectroscopy line data impact retrievals **?¿?**

BIRRA — Beer InfraRed Retrieval Algorithm

Separable least squares fit: $\mathbf{min}_{\boldsymbol{x}} \|y - F(x)\|^2$

$$F(x) \equiv \widehat{I}(\nu) = \frac{r(\nu)}{\cos\theta} I_{\text{sun}}(\nu) \exp\left[-\sum_m \alpha_m \tau_m(\nu)\right] \otimes \mathcal{S}(\nu,\gamma) + b$$

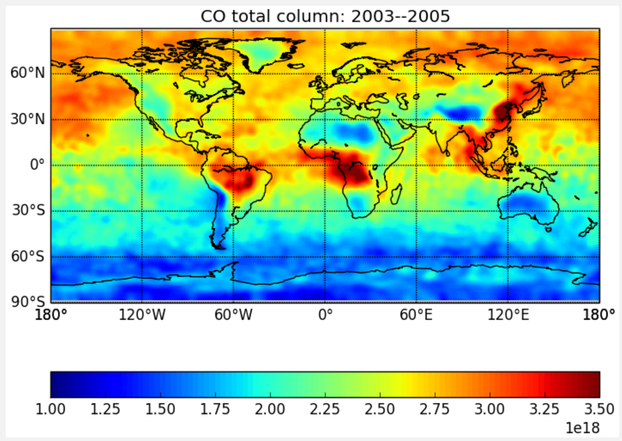
τ_m molecular optical depth; $\mathcal{S}$ spectral response function; θ SZA; b baseline

CO from SCIAMACHY

- Calibrated spectra normalized by SCIA sun measured spectrum
- Spectral window: 4283 – 4302 cm^{-1}
- Fit vector x:
  - scaling factors α_m of absorbers CO, CH_4, H_2O
  - coefficients r_0, r_1, r_2 of 2nd-degree reflectivity polynomial
  - half width γ of instrument slit function

"Product"

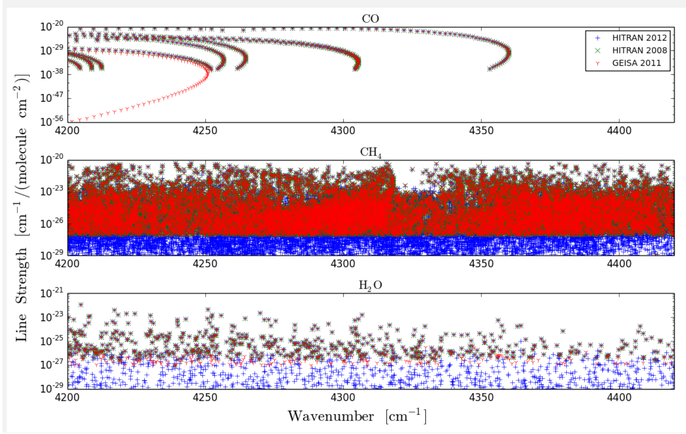
$$\text{xCO} \equiv \frac{\alpha_{CO}}{\alpha_{CH4}} \text{VCD}_{CO}^{ref}$$

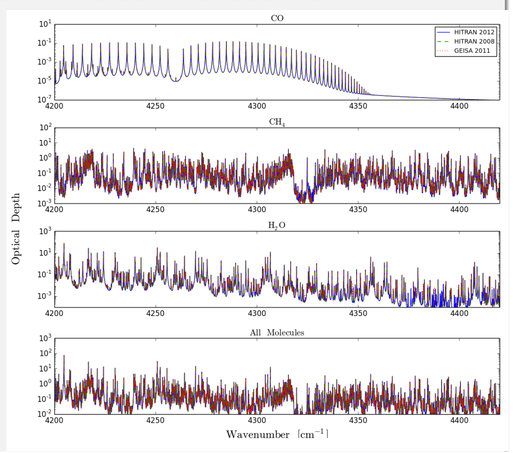


Molecular Spectroscopic Databases

CO Hitran 12: update based on Malathy-Devi work
CH_4 Hitran 12: 70% of lines replaced, S threshold decreased
H_2O Hitran 12: number of lines $\approx$ doubled

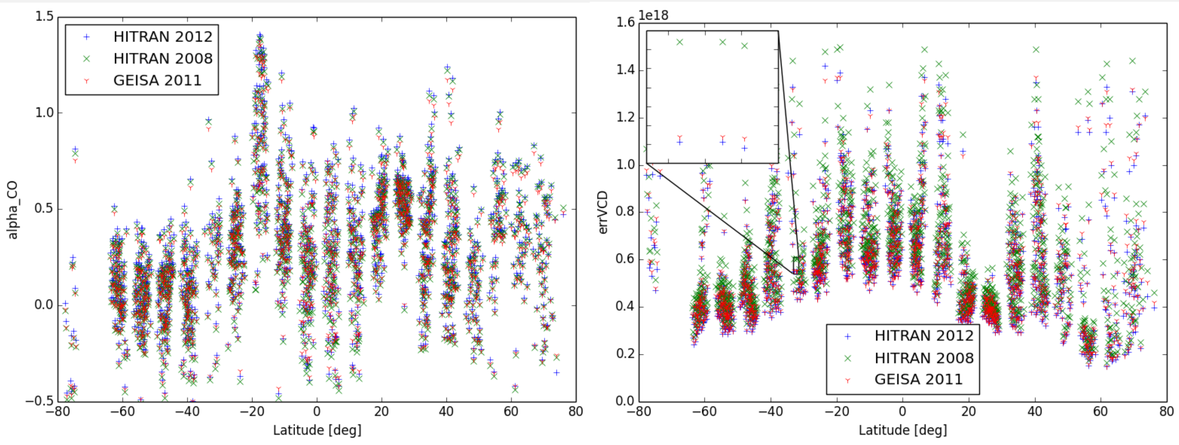
lines in 4273–4312 cm^{-1}			$S\,[\frac{cm^{-1}}{molec\,cm^2}]$	$\gamma_L^{(0)}\,[cm^{-1}]$	n
	Hitran 08	85	$1.1\cdot10^{-36} - 3.5\cdot10^{-21}$	0.042 – 0.068	0.67 – 0.75
CO	Geisa 11	85	$1.1\cdot10^{-36} - 3.5\cdot10^{-21}$	0.040 – 0.068	0.69
	Hitran 12	85	$1.1\cdot10^{-36} - 3.5\cdot10^{-21}$	0.042 – 0.068	0.67 – 0.79
	Hitran 08	4329	$9.5\cdot10^{-28} - 3.1\cdot10^{-21}$	0.034 – 0.076	0.56 – 0.87
CH_4	Geisa 11	4329	$9.5\cdot10^{-28} - 3.1\cdot10^{-21}$	0.034 – 0.076	0.56 – 0.87
	Hitran 12	6051	$1.0\cdot10^{-29} - 2.9\cdot10^{-21}$	0.035 – 0.073	0.56 – 0.87
	Hitran 08	136	$2.6\cdot10^{-27} - 1.7\cdot10^{-23}$	0.018 – 0.098	0.13 – 0.77
H_2O	Geisa 11	169	$1.0\cdot10^{-27} - 1.7\cdot10^{-23}$	0.025 – 0.100	0.36 – 0.77
	Hitran 12	283	$1.2\cdot10^{-29} - 1.7\cdot10^{-23}$	0.004 – 0.098	0.24 – 0.77



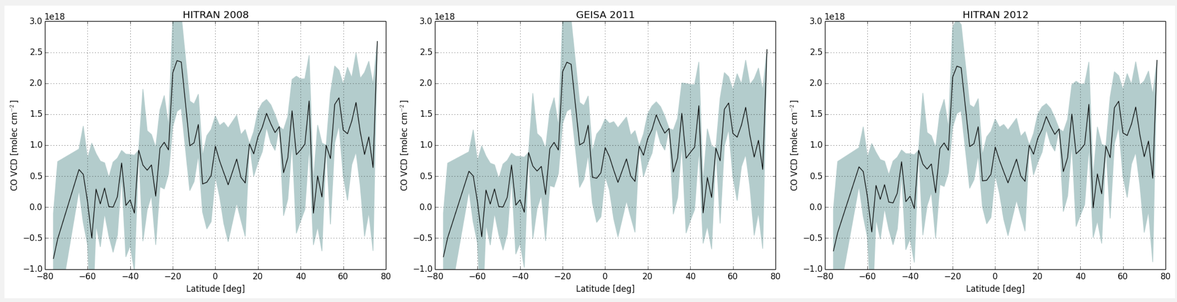


Orbit 8663 — October 2003

- Large land fraction: Russia, Arabian peninsula, East Africa
- Analysis of latitudinal dependence
- October: high CO over Africa due to biomass burning

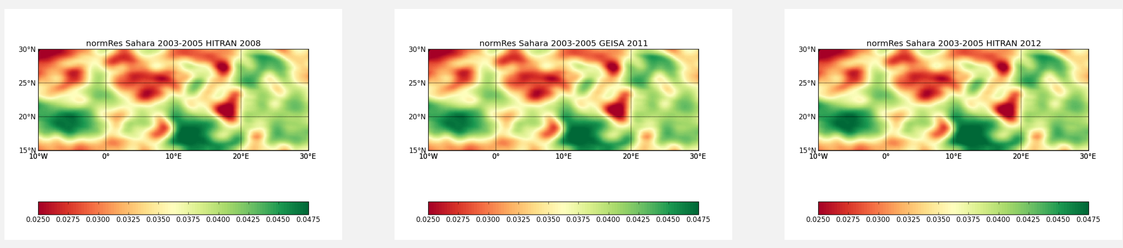


- No significant difference in residuals or number of "good" (converged, . . .) fits
- Small differences in scaling factors and xCO total column
- Errors of scaling factors smaller by about 8% for Hitran 2012

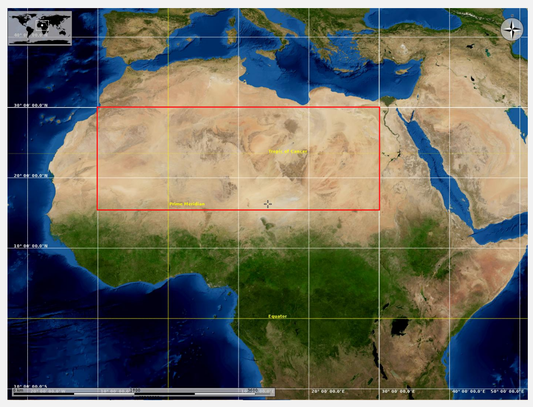


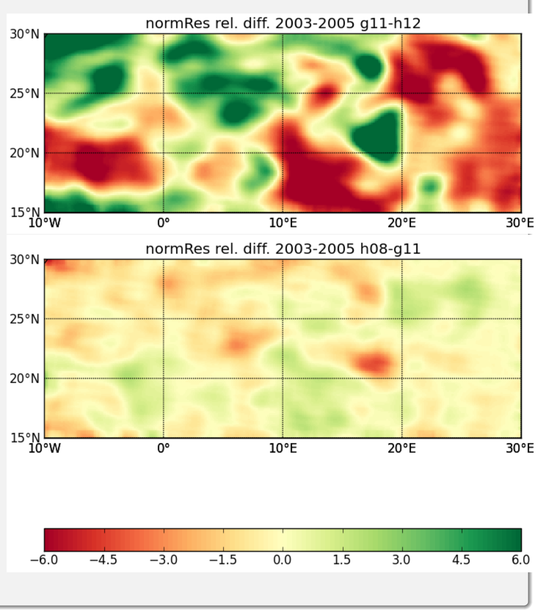
Sahara 2003 – 2005

- Analysis of spatial and temporal evolution
- Relative homogeneous terrain
- Largely cloud-free, high reflectivity, small SZA: high signal



- Residual norms almost identical for all 3 databases
- Residual norm relative differences resemble topography (correlation with surface albedo)





Conclusions

- For SCIAMACHY SWIR measurements recent databases do not show big differences
- HITRAN 08 $\approx$ GEISA 11 $\neq$ HITRAN 12
  more recent data appear to be "slightly" better
- Other retrieval settings presumably more important, esp. calibration
- Sentinel-5 Precursor: significantly better SNR
  spectroscopy has a big impact !!!