

Introduction

- ▶ SWIR spectra contain information about greenhouse gases (CO₂, CH₄, H₂O) and gases with indirect radiative forcing such as CO
- ▶ Down-looking SWIR spectra sensitive to the troposphere
⇒ SWIR region especially suitable to sources and sinks analysis
- ▶ Envisat-SCIAMACHY channels in the SWIR region:
 - Channel 8 mainly used for CO retrievals
 - Channel 6 exploited by most CH₄ and CO₂ retrievals
- ▶ Various auxiliary data required for Level 1→2 processing (Molecular spectroscopy data, climatology, ...)
- ! Verification: Intercomparison with independent retrievals
- ! *Validation*: Intercomparison with independent measurements !!!

BIRRA — Beer InfraRed Retrieval Algorithm

- ▶ Forward — SWIR radiative transfer — Intensity I vs. wavenumber ν

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

Molecular optical depth τ with line-by-line approach

$$\tau_m(\nu) = \int_{\text{sun-earth-sat}} ds n_m(s) \sum_l S_l(T(s)) g(\nu; \hat{\nu}_l, \gamma_l(p(s), T(s)))$$

n_m molecular number density;
 $\hat{\nu}_l, S_l, \gamma_l$ line position, strength, width; Voigt line shape g ;
 S spectral response function (SRF); θ SZA; \mathbf{b} baseline

- ▶ Inversion: Separable least squares fit

$$\min_{\alpha, \beta} \| \mathbf{y} - F(\alpha, \beta) \|^2$$

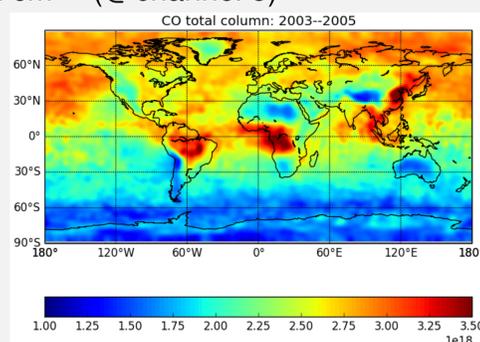
State vector $\mathbf{x} = (\alpha, \beta)$ of nonlinear (molec. scaling factors) and linear (reflectivity r , baseline \mathbf{b}) parameters

- ▶ BIRRA — two versions:
 - ▶ “scientific” prototype version (This work!!!)
 - ▶ operational ∈ SCIAMACHY level 1b-2 processor (v6.0)

CO from SCIAMACHY

- ▶ Calibrated spectra normalized by SCIA sun measured spectrum
- ▶ Spectral window: 4283 – 4302 cm⁻¹ (∈ channel 8)

- ▶ Fit vector \mathbf{x} :
 - ▶ scaling factors α_m of absorbers **CO**, **CH₄**, **H₂O**
 - ▶ coefficients r_0, r_1, r_2 of 2nd-degree reflectivity polynomial
 - ▶ SRF half width γ
- ▶ “Product”
 $x\text{CO} \equiv \frac{\alpha_{\text{CO}}}{\alpha_{\text{CH}_4}} \text{VCD}_{\text{CO}}^{\text{ref}}$
(proxy-normalized column)



Ground-based Fourier Transform

NDACC (Network for Detection of Atmospheric Composition Change)

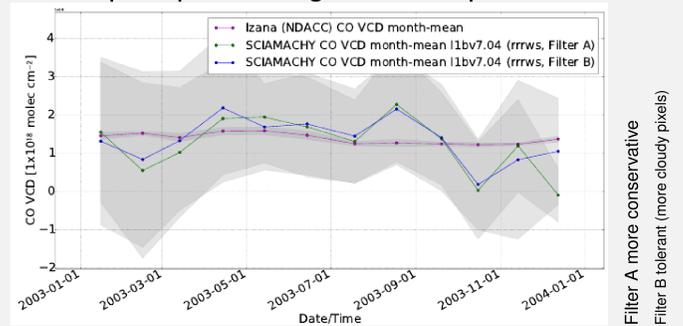
- ▶ CO and CH₄ from mid IR (unlike SCIA)
- ▶ some dozen stations, mostly operational since 2 decades

TCCON (Total Carbon Column Observing Network)

- ▶ CO and CH₄ from near IR (like SCIA)
- ▶ most stations operational only in last decade (only few data for early SCIAMACHY years)

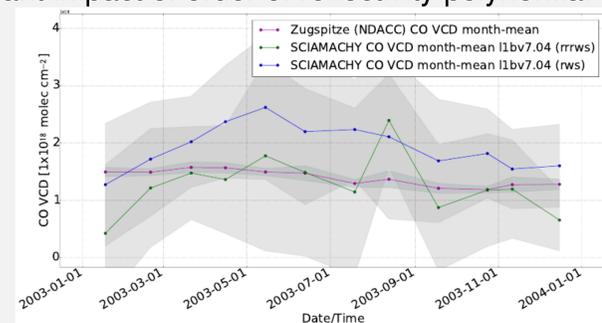
CO Validation

- ▶ Importance of post-processing: filter “suspicious” data



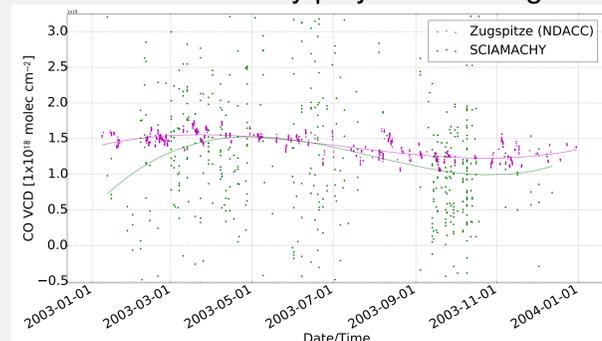
Filter A more conservative
Filter B tolerant (more cloudy pixels)

- ▶ Significant impact of order of reflectivity polynomial

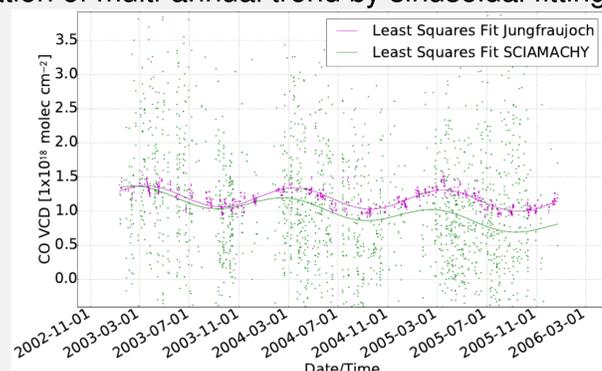


Note: Instrument anomaly in August!

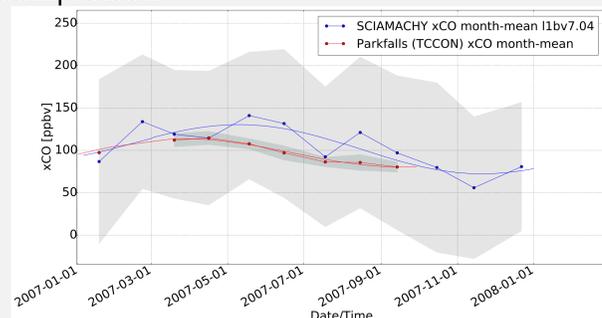
- ▶ Visualization of annual trend by polynomial fitting



- ▶ Visualization of multi-annual trend by sinusoidal fitting



- ▶ TCCON comparison



Summary

- ▶ **CO** BIRRA vs. NDACC/TCCON within error bars
Evidence of degrading channel 8 detector in later years
- ▶ Impact of level 0-1 processing
Impact of level 1-2 BIRRA settings
Impact of level 2 filtering and coincidence criteria

Further reading: S. Gimeno Garcia et al., AMT 4, 2633, 2011