Satellite and ground-based total ozone retrievals in the Huggins and Chappuis bands

… a DOAS perspective on ozone absorption cross-sections

Michel Van Roozendael and Christophe Lerot

BIRA-IASB, Brussels, Belgium

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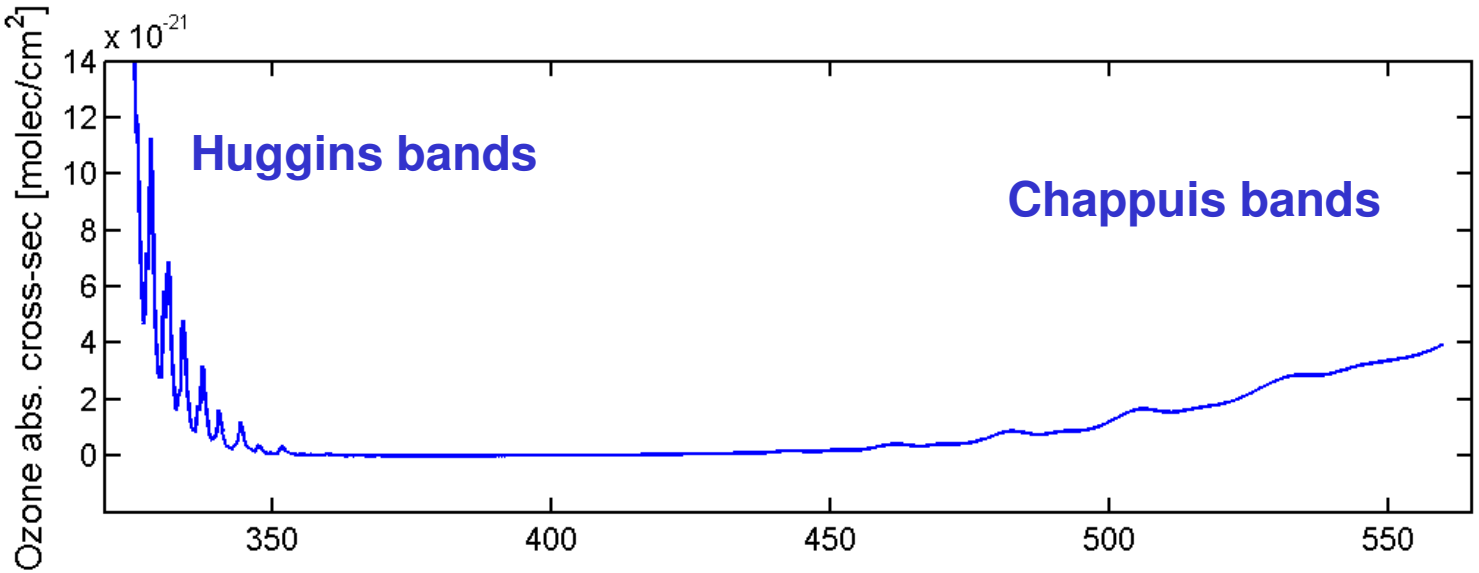
Introduction

- What do we need ? → a DOAS community perspective

- **O_3 cross-sections for ozone retrievals**
  - Huggins: approx. 315-360 nm
  - Chappuis: approx. 450-650 nm
    - High resolution (Huggins)
    - Low noise
    - Full temperature dependence (Huggins)
    - Accurate wavelength registration (Huggins)
    - Consistency over full range of wavelength
    - Absolute accuracy of « differential structures »

- **O_3 cross-sections for trace gas retrievals**
  - Accuracy of spectral shape matters most

What is relevant for DOAS ?



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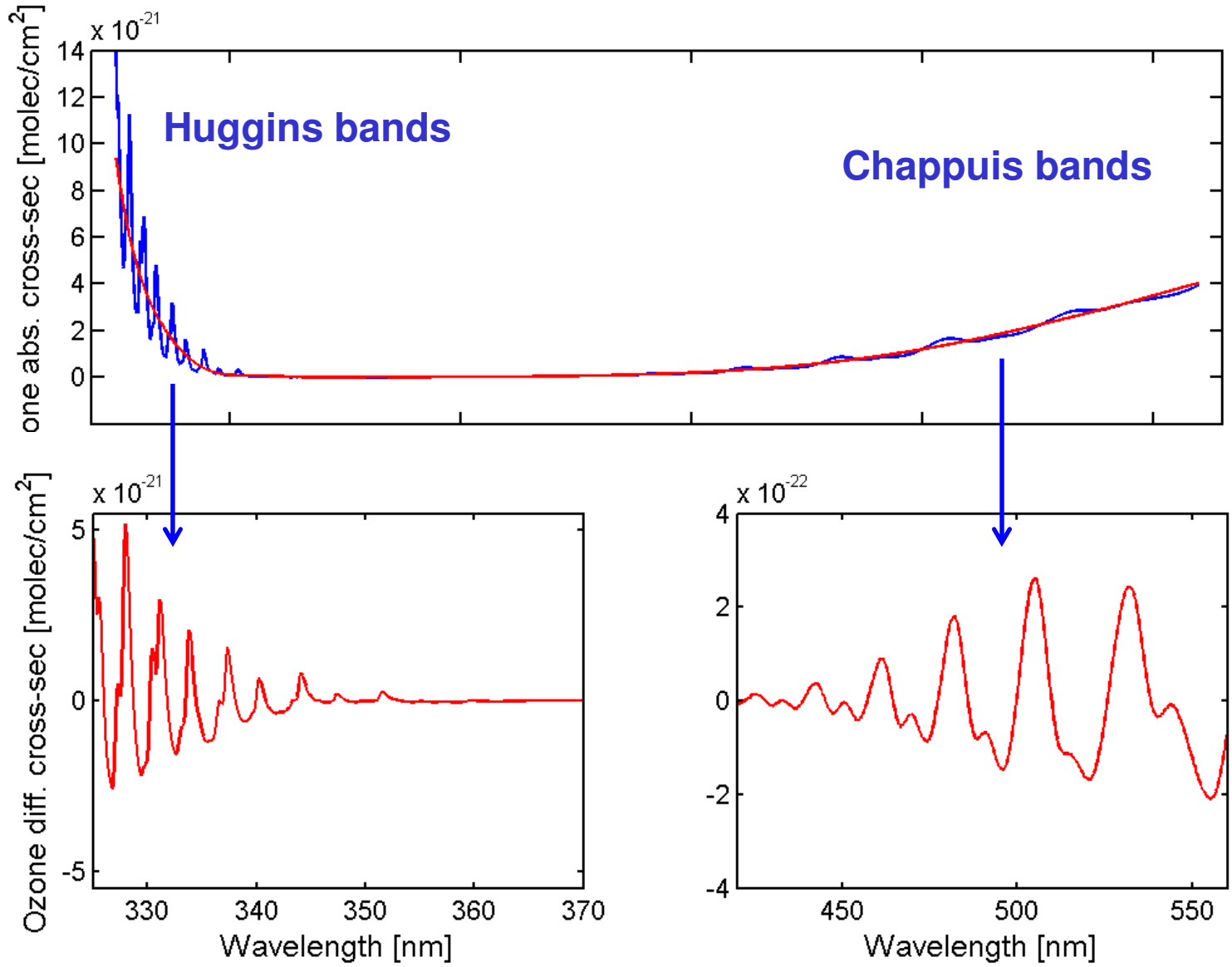
→ Differential cross-sections



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What can we possibly diagnose using DOAS ?

- ✓ Accuracy of wavelength registration
- ✓ Accuracy of spectral shape
- ✓ Temperature dependence
- ✓ … ??

- ❑ Our experience:
  - ➢ GOME total ozone → DOAS and direct-fitting retrievals in the Huggins bands (the GODFIT project)
  - ➢ NDACC → ground-based zenith-sky twilight retrievals mostly in Chappuis bands

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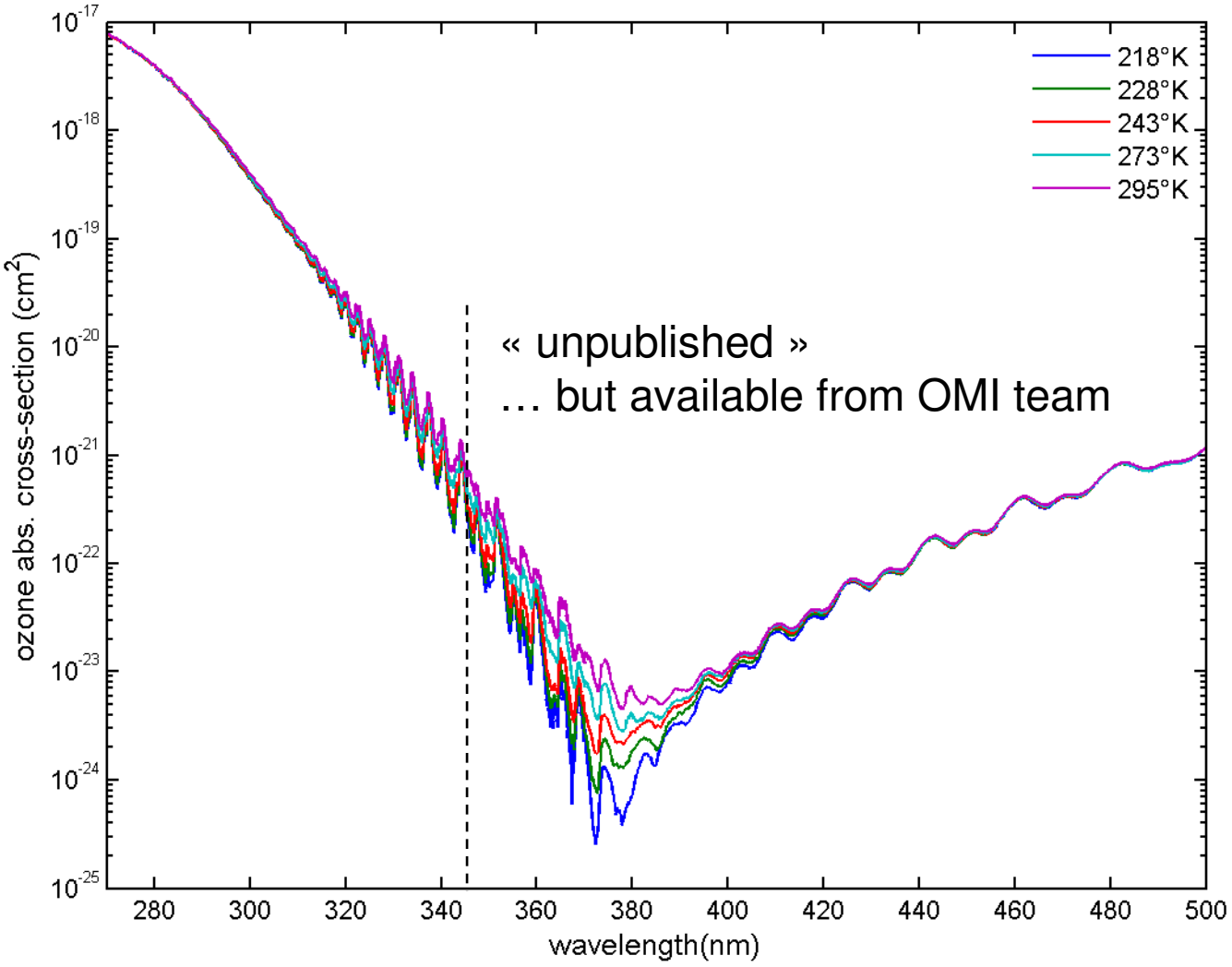
Cross-section data sets

- Bass & Paur, 1985 (Huggins bands only)
- Brion et al. (BMD), 1992, 1993, 1995
- Burrows et al., 1999 (GOME FM98)
- Bogumil et al., 2003

Brion et al. – how far does it go really ??



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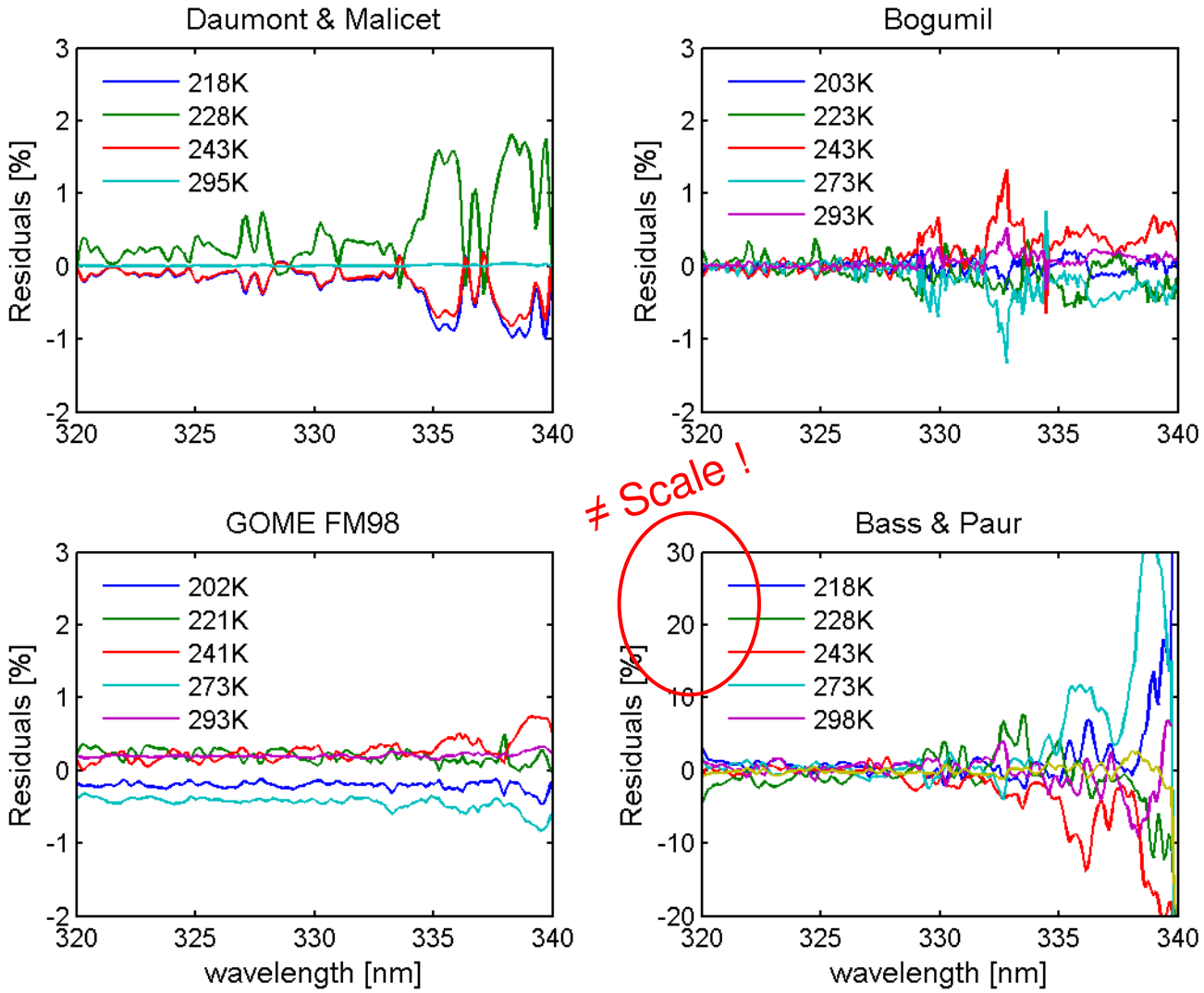
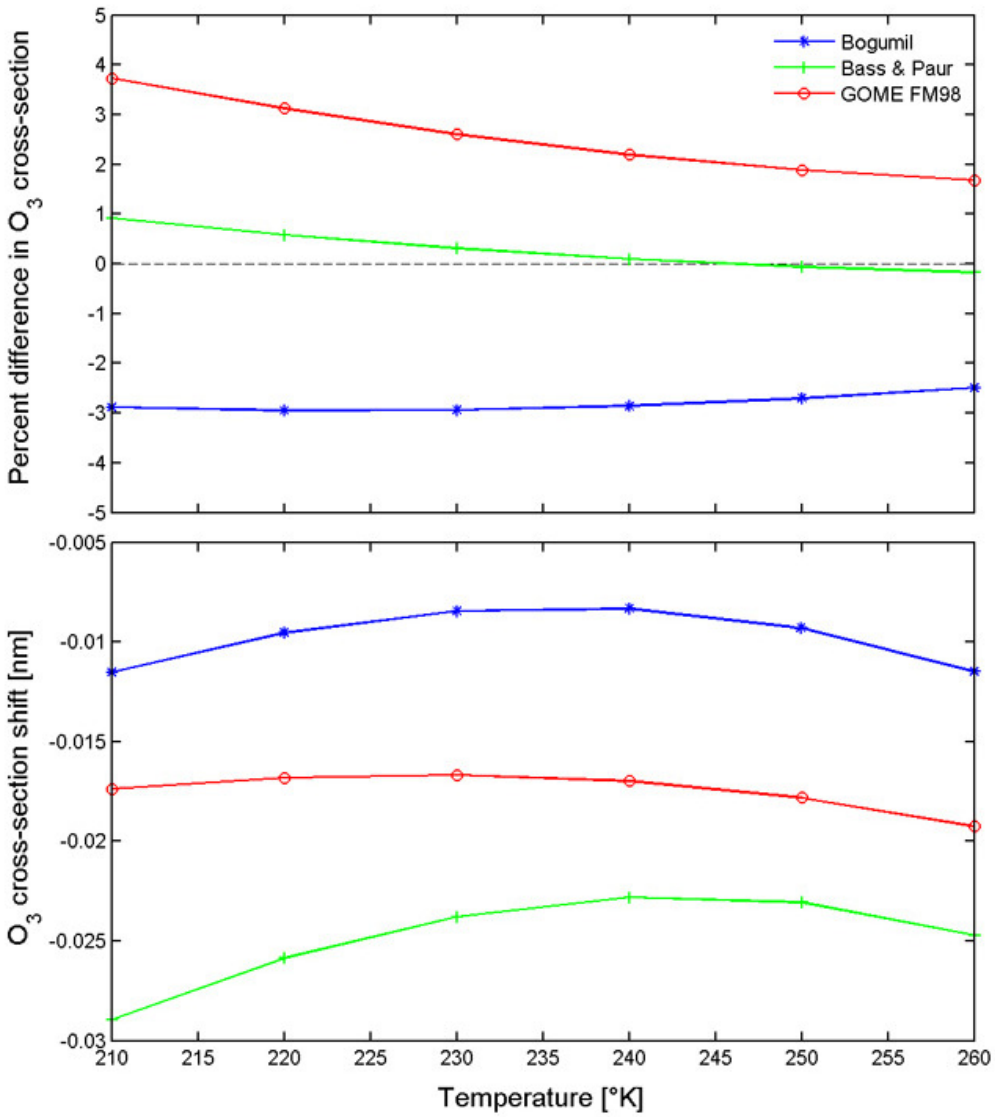
Consistency of temperature dependence ?

→ deviations w.r.t. quadratic parameterization



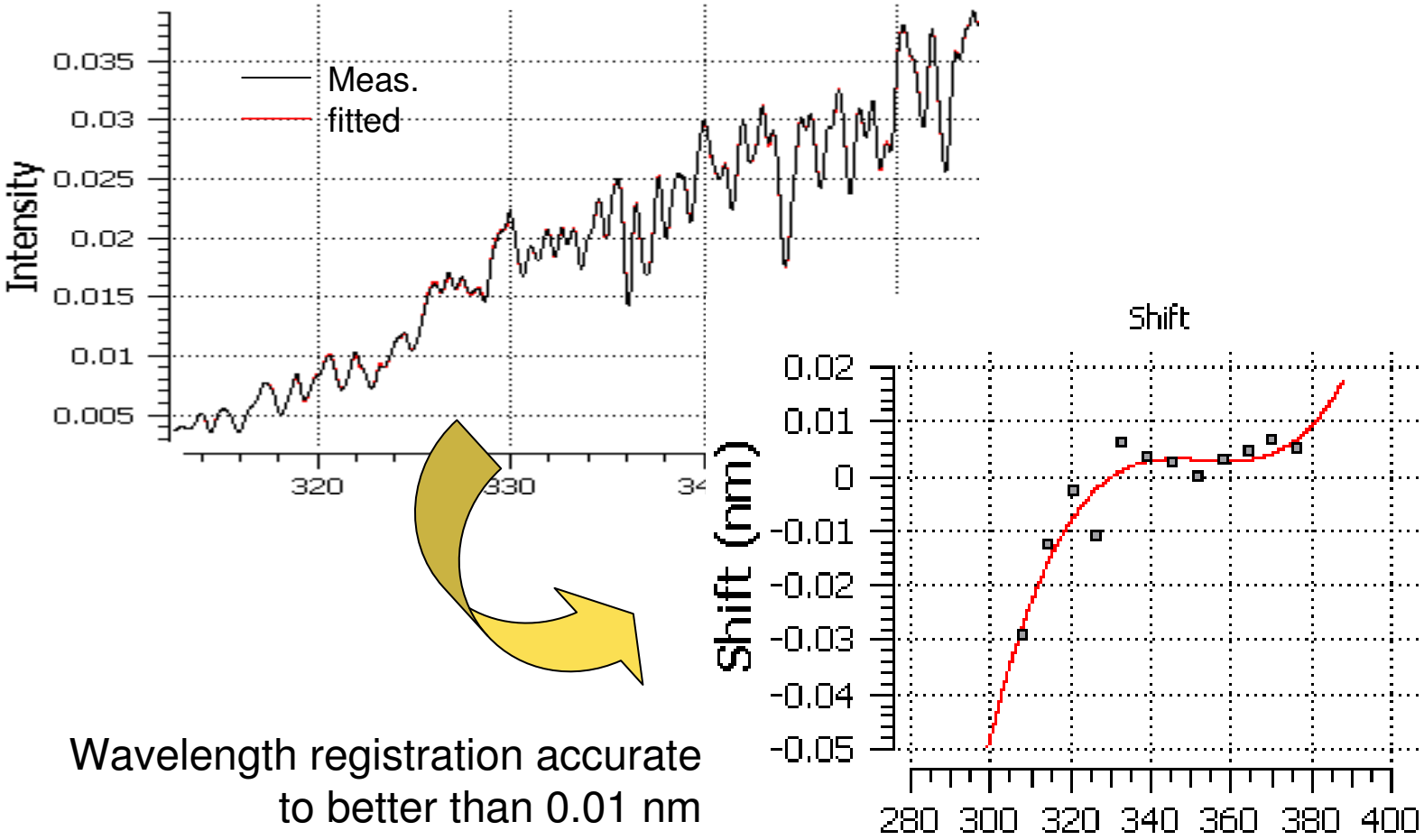
Differences relatives to Brion et al.



- 320 – 340 nm, SCIAMACHY resolution
- Quadratic parametrization applied to all data sets → all data sets can be compared at same T°
- Large differences between Bogumil (SCIAMACHY) and Burrows (GOME FM). Largest differences at lowest temperatures

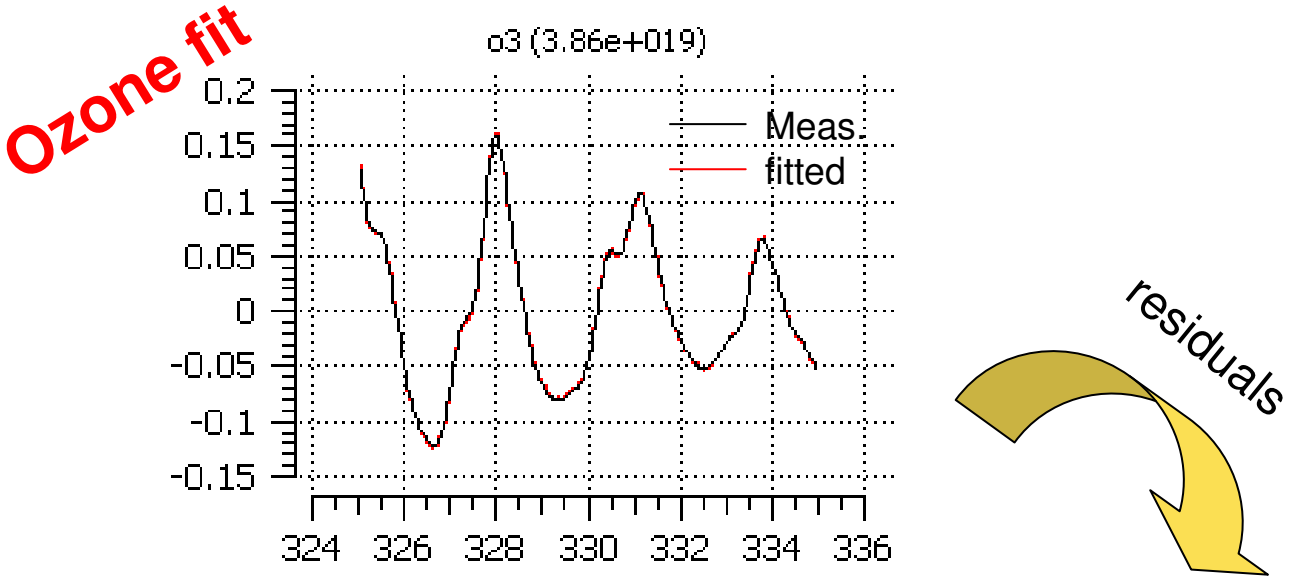
Diagnose accuracy of wavelength registration using DOAS

Fit to solar lines, using highly accurate atlas (Kurucz)



Wavelength registration accurate to better than 0.01 nm

Diagnose ozone cross-section shifts from atmospheric spectra



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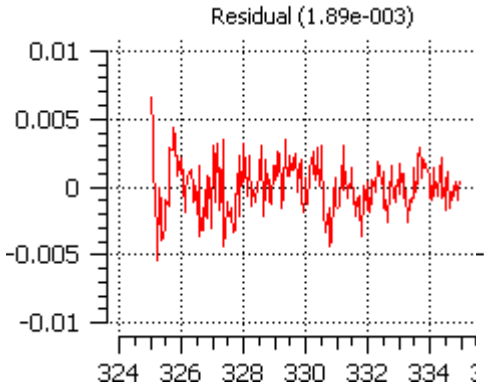
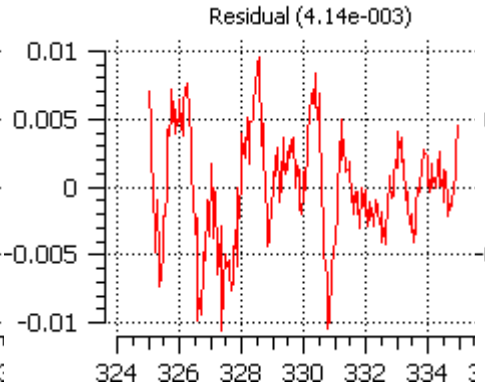
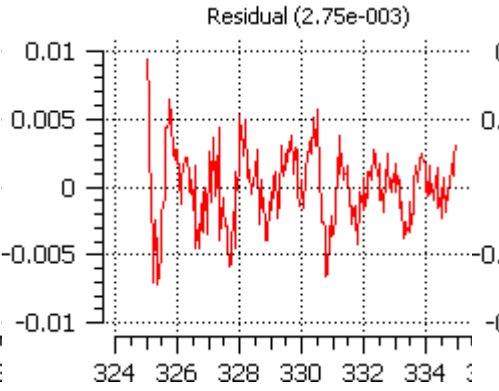
Brion et al



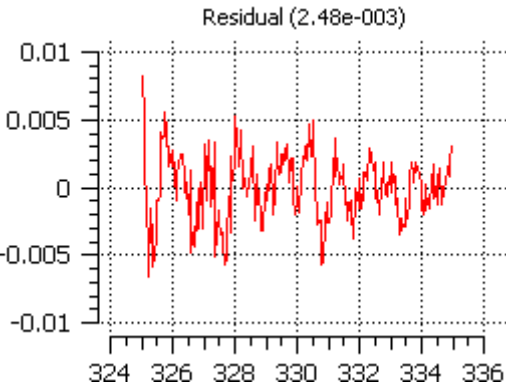
B & P



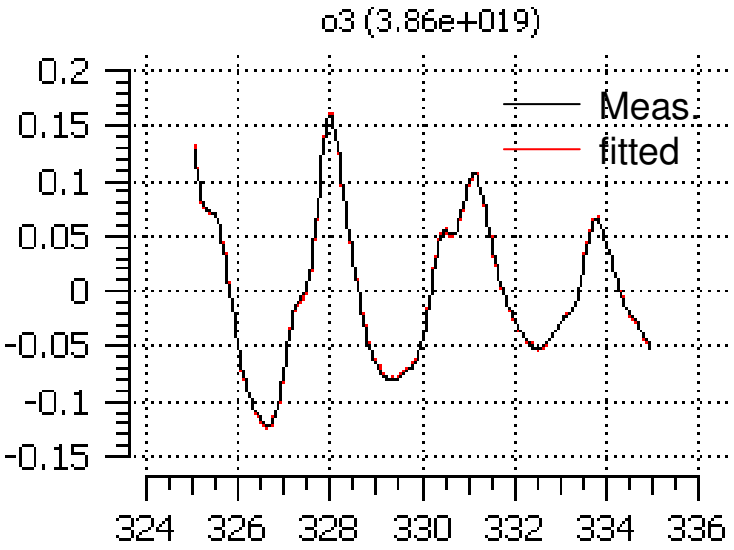
GOME FM

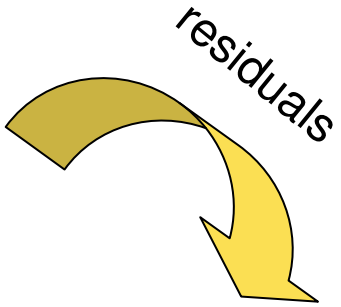


Bogumil



Diagnose ozone cross-section shifts from atmospheric spectra





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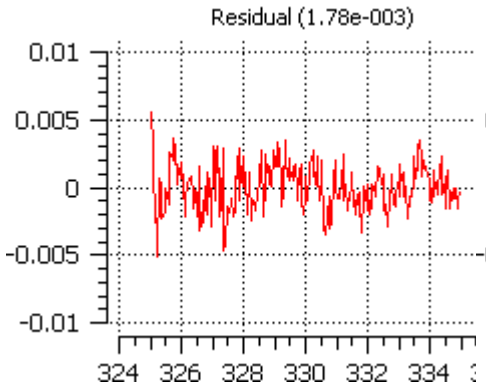
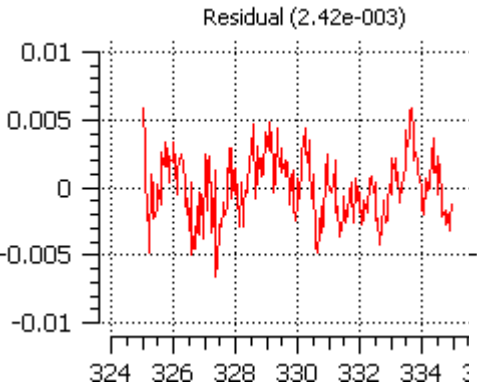
Brion et al



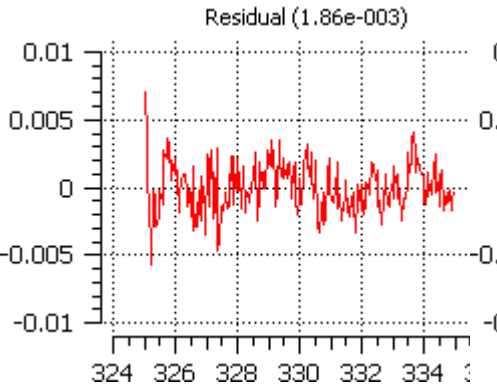
Shift: 0.005 nm

B & P



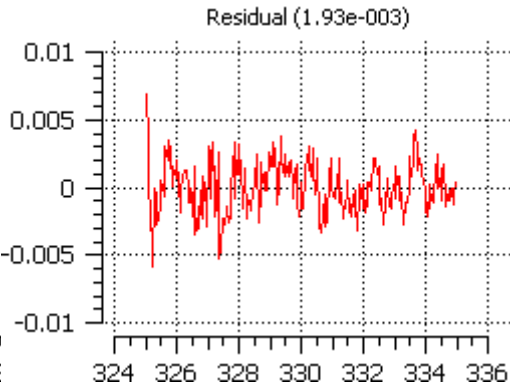
0.03 nm

GOME FM



0.025 nm

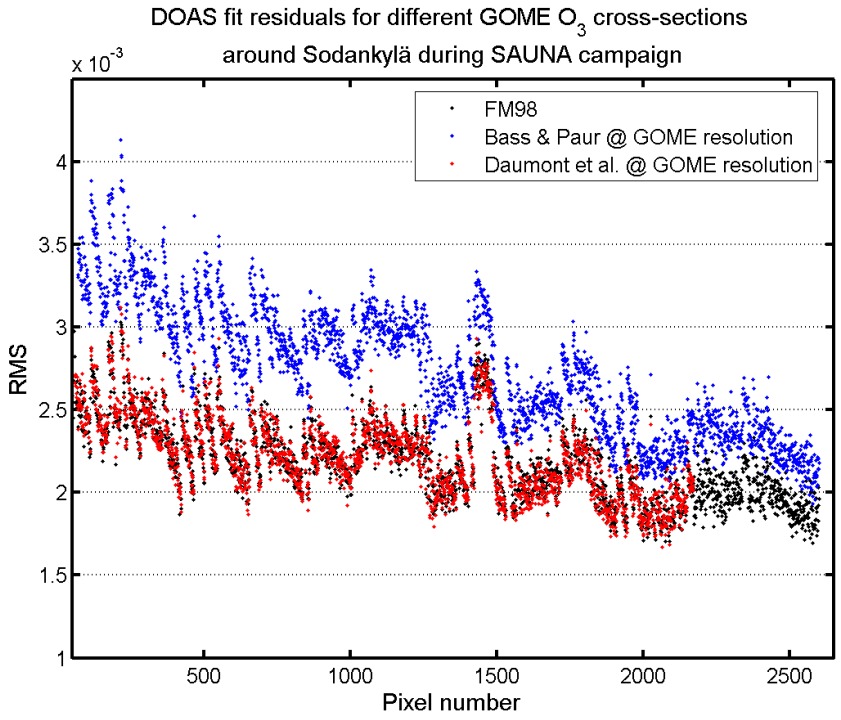
Bogumil



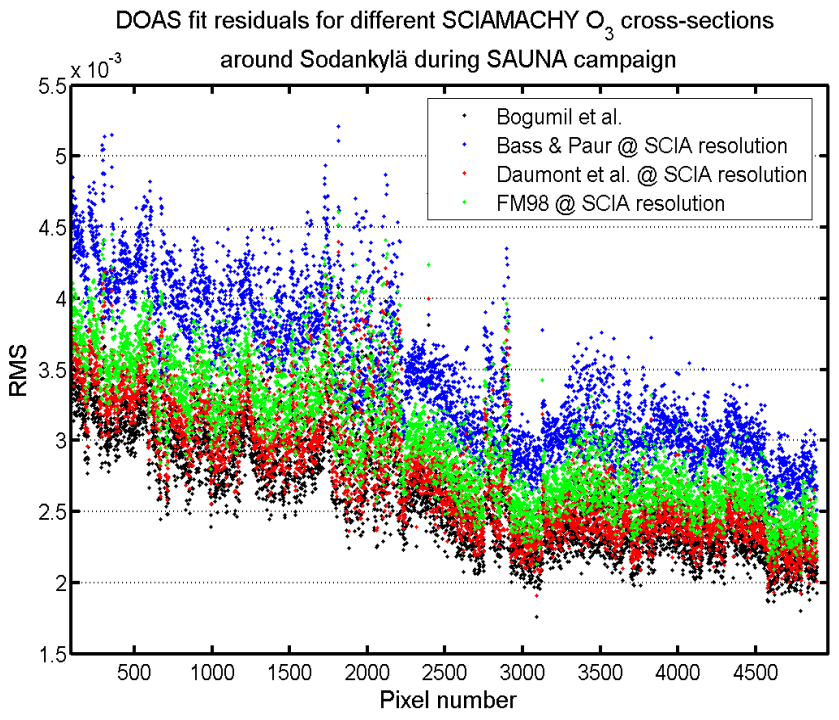
0.018 nm

Fitting residuals in satellite retrievals
→ Huggins bands, 325-335 nm

GOME



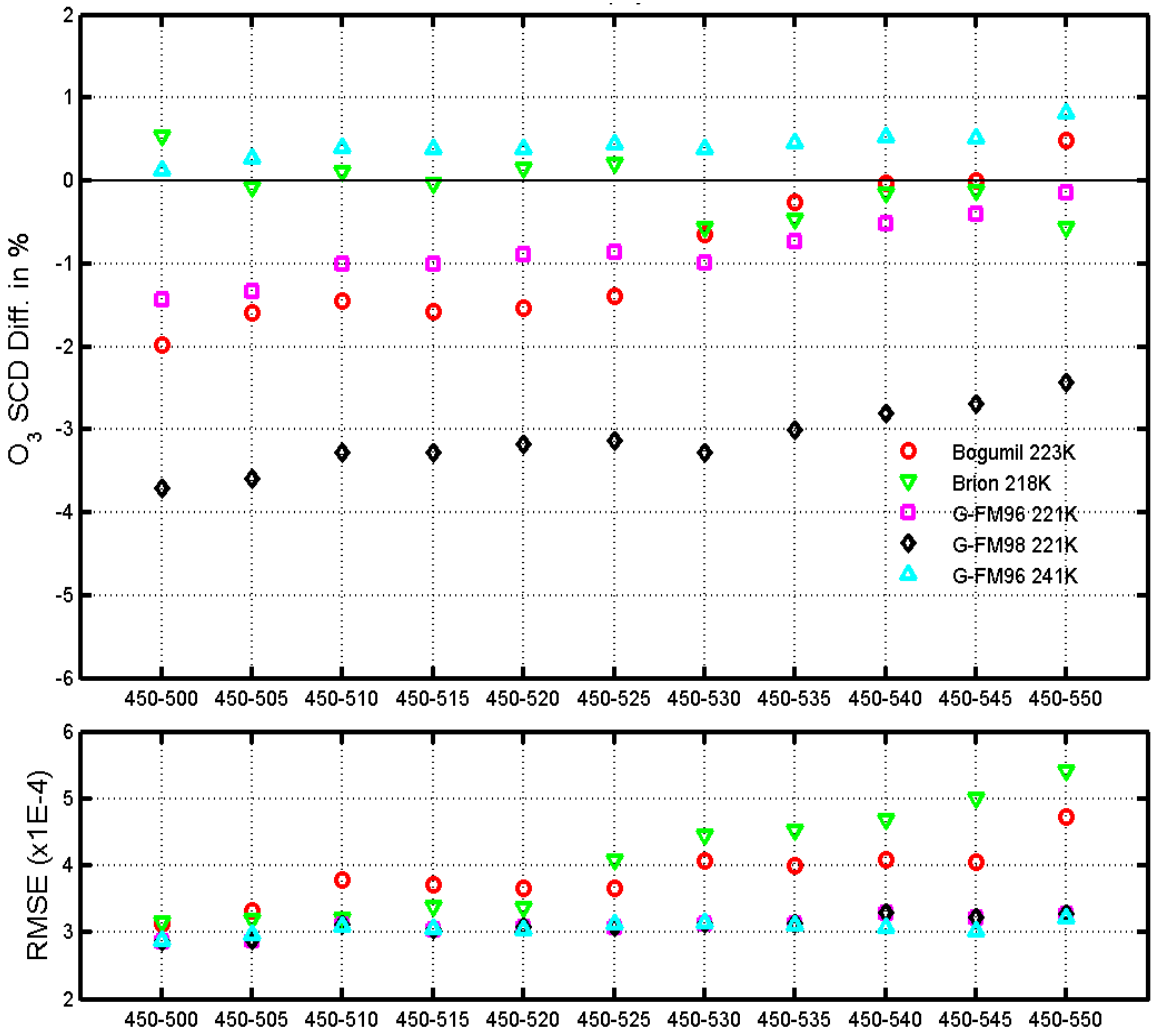
SCIAMACHY



For GOME, best residuals are obtained with **FM98** and **Brion et al.**

For SCIAMACHY, **Bogumil et al.** and **Brion et al.** also perform similarly

Fitting residuals cont. → Chappuis bands, 450-550 nm



- Ground-based (Harestua)
- Best residuals obtained with GOME FM
- 3% offset between GOME FM98 and GOME FM96 !
- GOME FM96 agrees well with Brion et al.

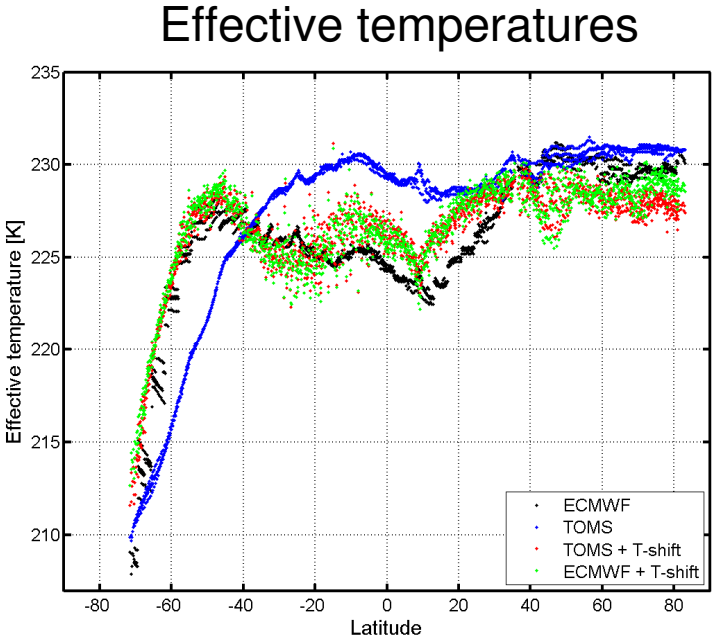
Testing the accuracy of the temperature dependence of the O_3 cross-sections

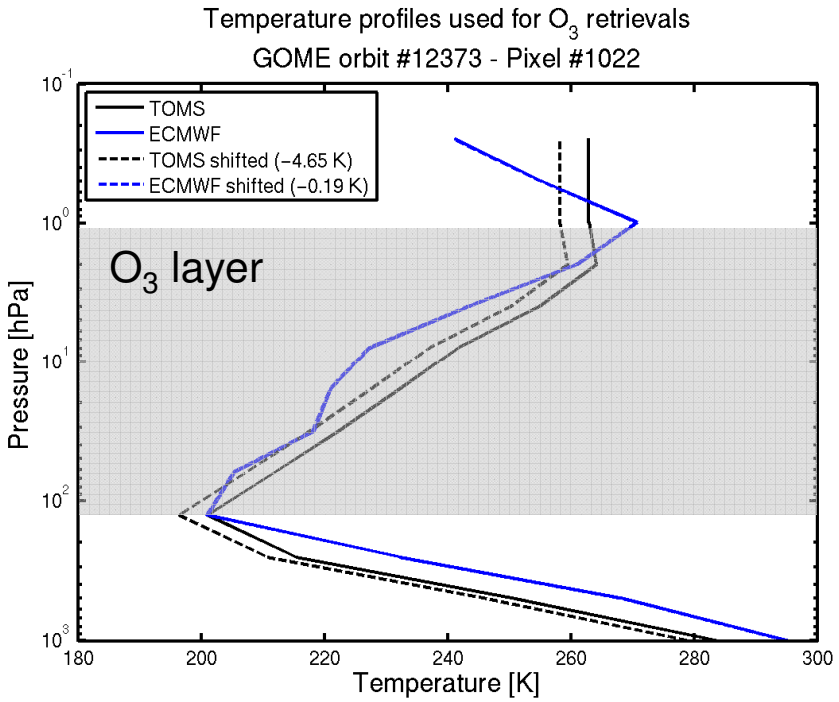
- **The GODFIT retrieval tool and its T°-shifting facility**
  - GODFIT = GOME Direct-fitting (BIRA, RT-Solutions, DLR consortium). Basis for next version of ESA GOME total ozone data product (GDP 5)
  - Total ozone retrieval tool for GOME, based on LIDORT
  - Full spectral fit to measured GOME radiances in 325-335 nm interval
  - T°-shift → adjust the a-priori atmospheric T° profile to match at best the observed O_3 absorption

- We focus on the concept of **effective T°**, i.e. the mean T° weighted by the ozone profile

Example:

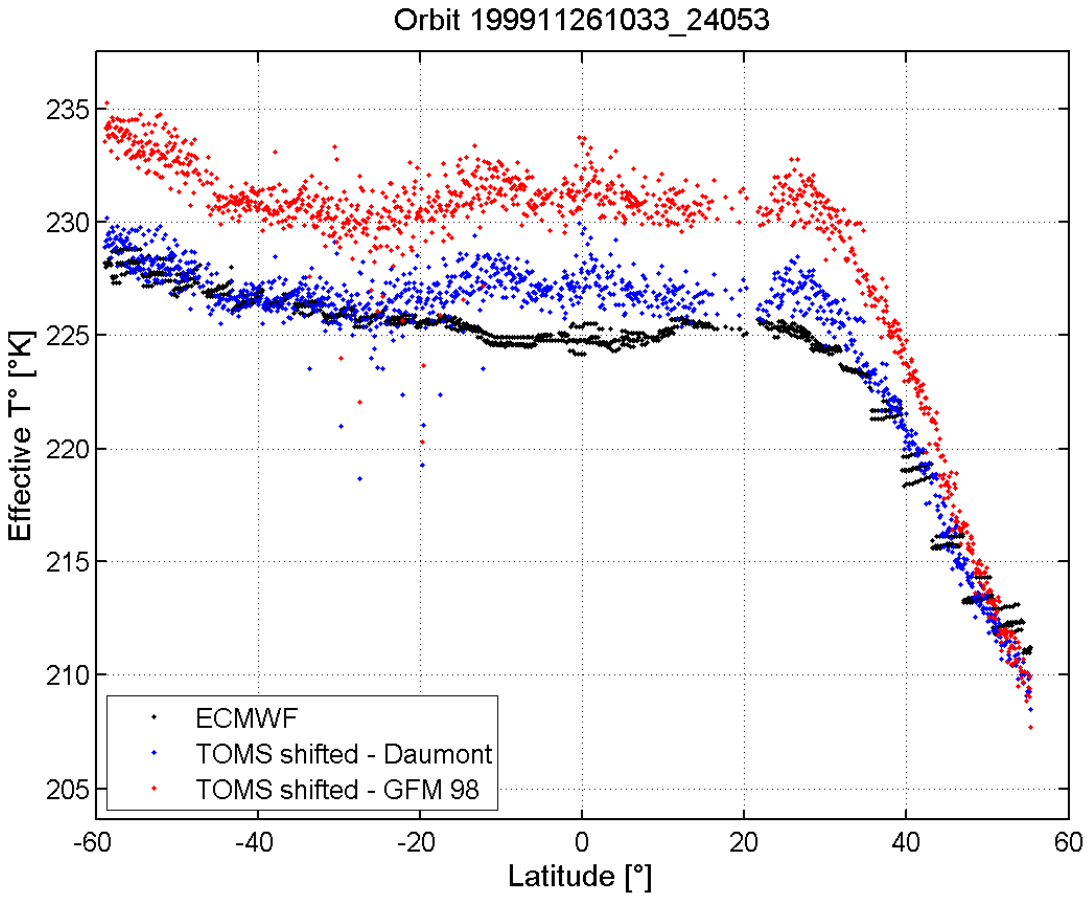
GDP 5
T-shift process





→ Retrieved effective temperatures are highly consistent with ECMWF T° extracted at GOME overpass.

Comparing Brion and GOME FM98 cross-sections

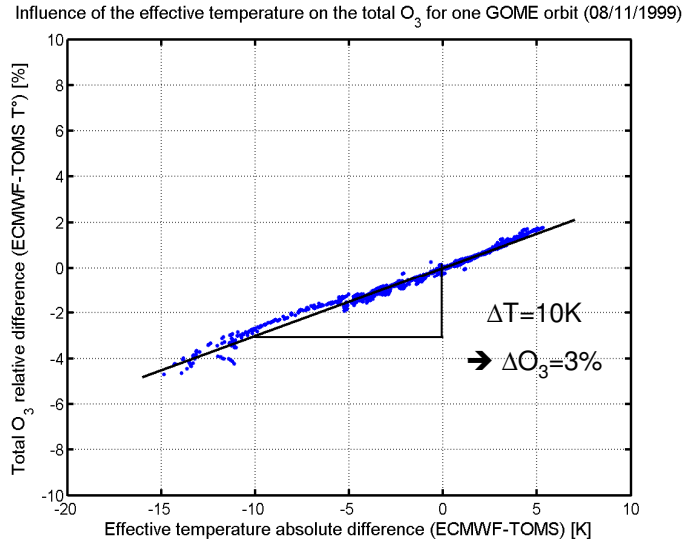


➔ In contrast to Brion et al., GOME FM98 produces a systematic 5-10°K bias on the GODFIT retrieved temperatures

Note on error compensation effects

GOME FM98 cross-sections have been succesfully used in the past for ozone retrievals (cf. GDP 4) → why ?

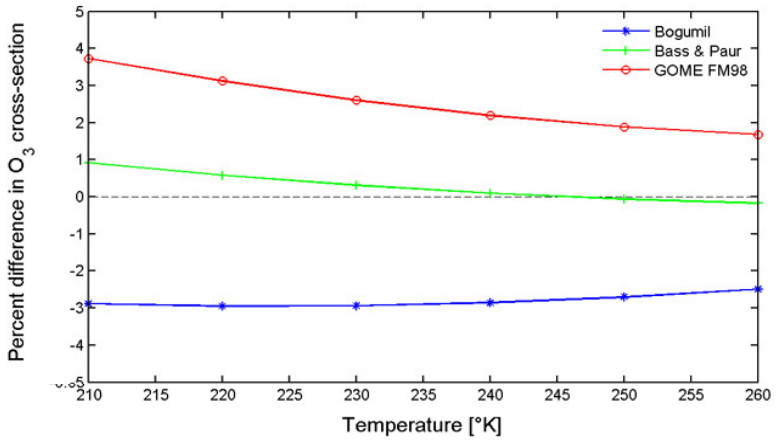
1. Effective temperatures too high



→ The O_3 columns are 3% too high

2. GOME FM98 cross-sections 3% higher than Brion et al.

Differences w.r.t. to Daumont et al.

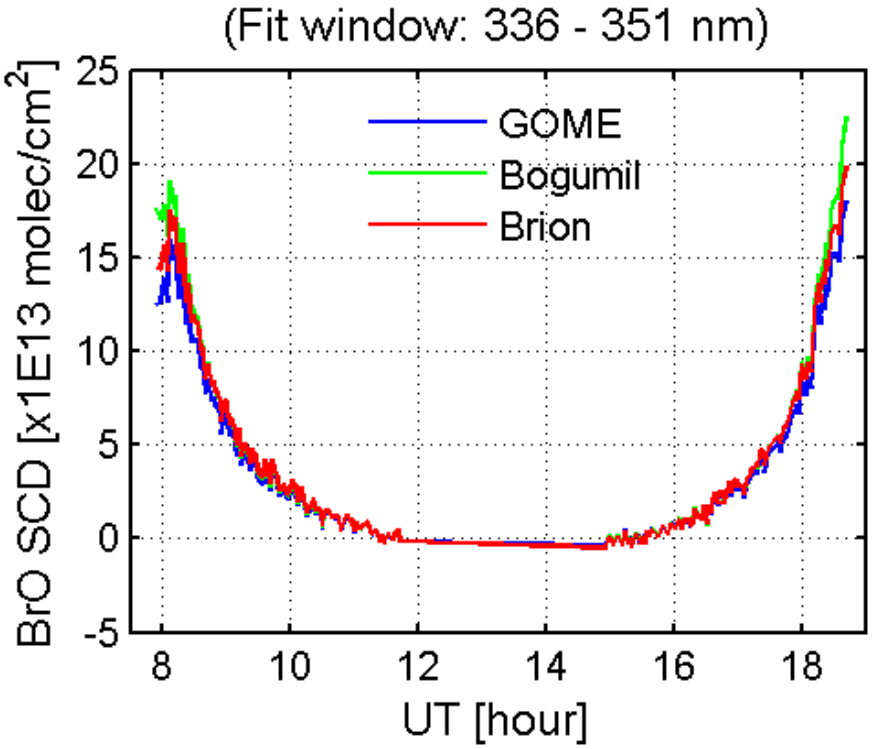


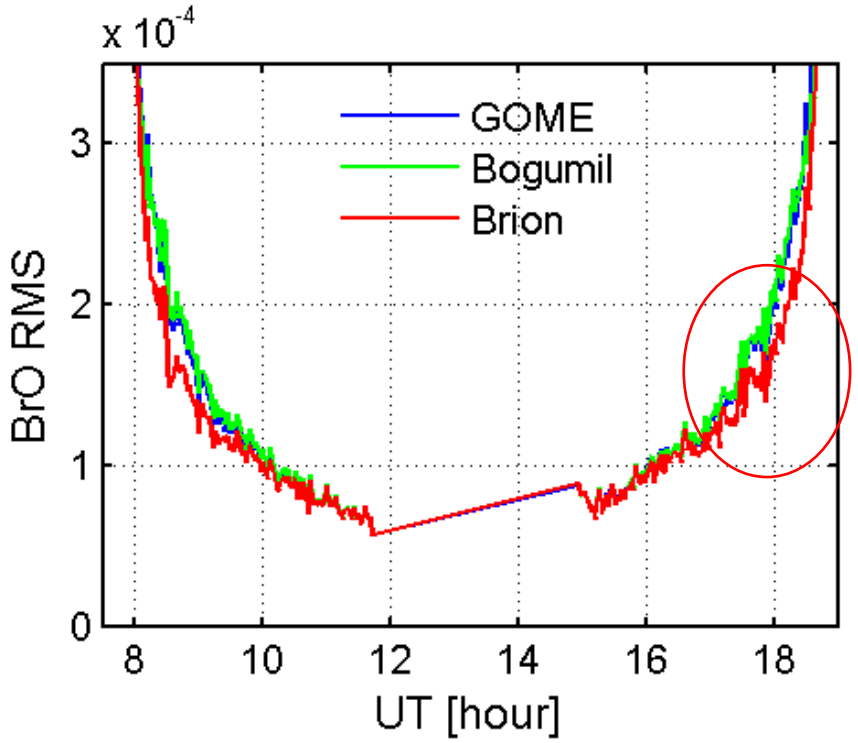
→ Using FM 98 data leads to O_3 columns 3% lower than the columns derived using the Brion et al. data.

→ Compensation between these two effects.

→ Total O_3 columns in good agreement with correlative data.

Impact on minor trace gases, e.g. BrO





- The « unpublished » longer wavelength Brion et al. data set is doing quite a good job for minor trace gas retrievals as well → best residuals for BrO fitting in 336-351 nm region.

Summary

- DOAS retrievals can help in diagnosing several aspects of the quality/reliability/consistency of ozone absorptions cross-sections
  - Accuracy of wavelength registration
  - Accuracy of spectral shape (fitting residuals)
  - Accuracy of temperature dependence

	Brion	B & P	GOME FM	Bogumil
Wavelength calib.	+	--	-	-
Spectral shape	++	--	+	+
T° dependence	++	?	+	+

- Our current rating:
  - In Huggins bands: Brion et al. (BMD)
  - In Chappuis bands: Bogumil et al. (best cross-section overall in Chappuis); GOME-FM96 (best residuals in 450-550 nm)