



A consistent long-term total ozone data record based on GOME, SCIAMACHY and GOME-2 as part of the ESA Climate Change Initiative

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Ozone is one of the atmospheric Essential Climate Variables (ECVs) under focus as part of the ESA's Climate Change Initiative (CCI) programme. The Ozone_cci project aims at producing, from multiple satellite sensors, consistent and properly characterised global long-term ozone data series that meet the requirements from the climate research community.

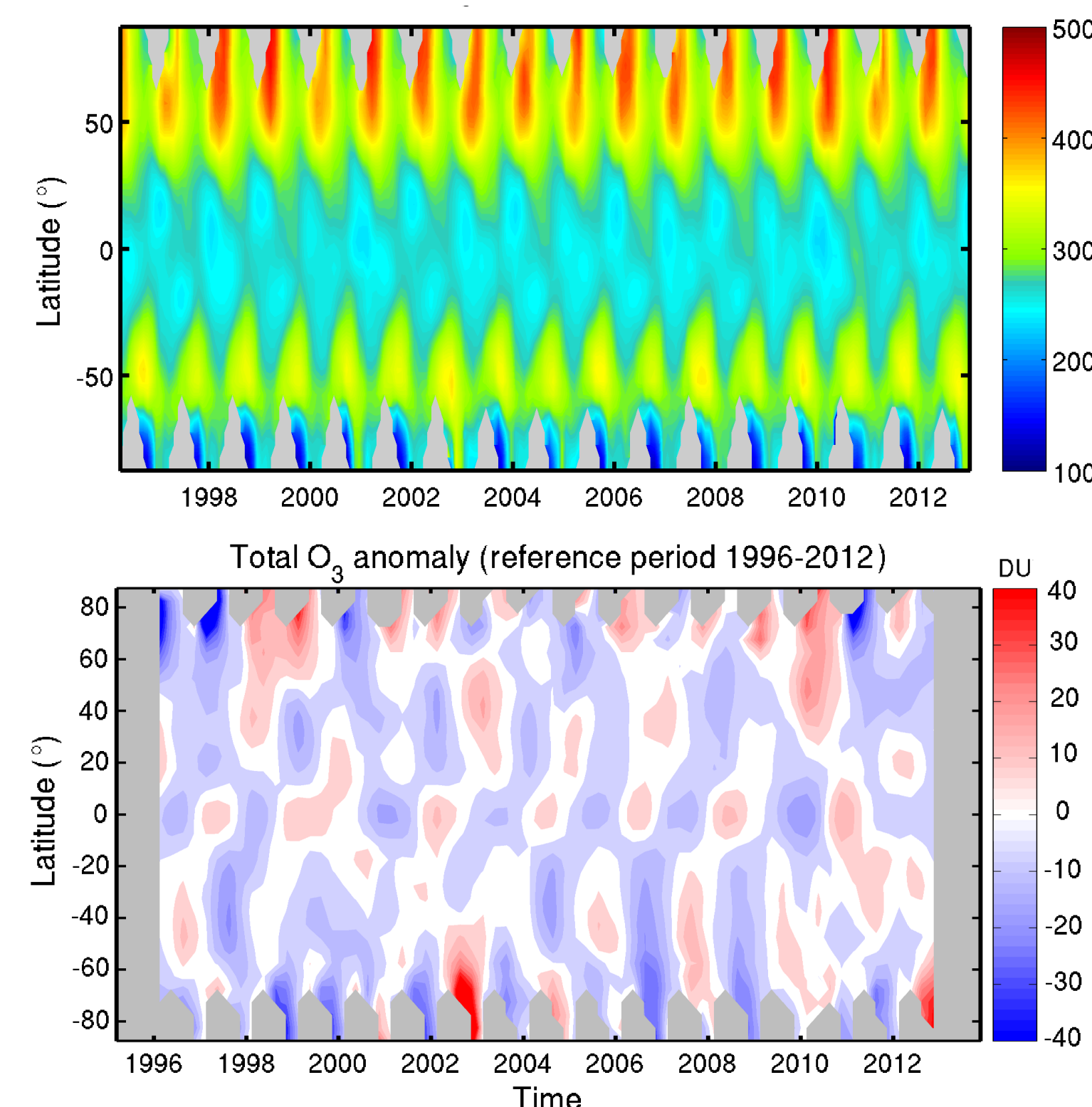
We present a new fully reprocessed total ozone data set combining GOME, SCIAMACHY and GOME-2 observations over the period from 1996 until 2012. All sensors are processed in a fully consistent way using a state-of-the-art direct-fitting algorithm set up using harmonised assumptions and input data bases. The retrieval algorithm GODFIT (GOME-type Direct-FITting) uses a non-linear least-squares adjustment of LIDORT-based spectral simulations of the backscattered earthshine radiance to measured spectra in the 325-335 nm interval. In addition a new soft-calibration scheme has been developed, that optimises the consistency of the input level-1 radiances from all sensors. This results in a level-2 total ozone data record from 3 European sensors covering more than 17 years with unprecedented consistency. We present here the main features of the data sets and some comparisons with other existing total ozone data sets are also discussed. Validation results using independent ground-based reference data sets are presented in a companion poster by M. Koukouli et al.

The GODFIT algorithm¹

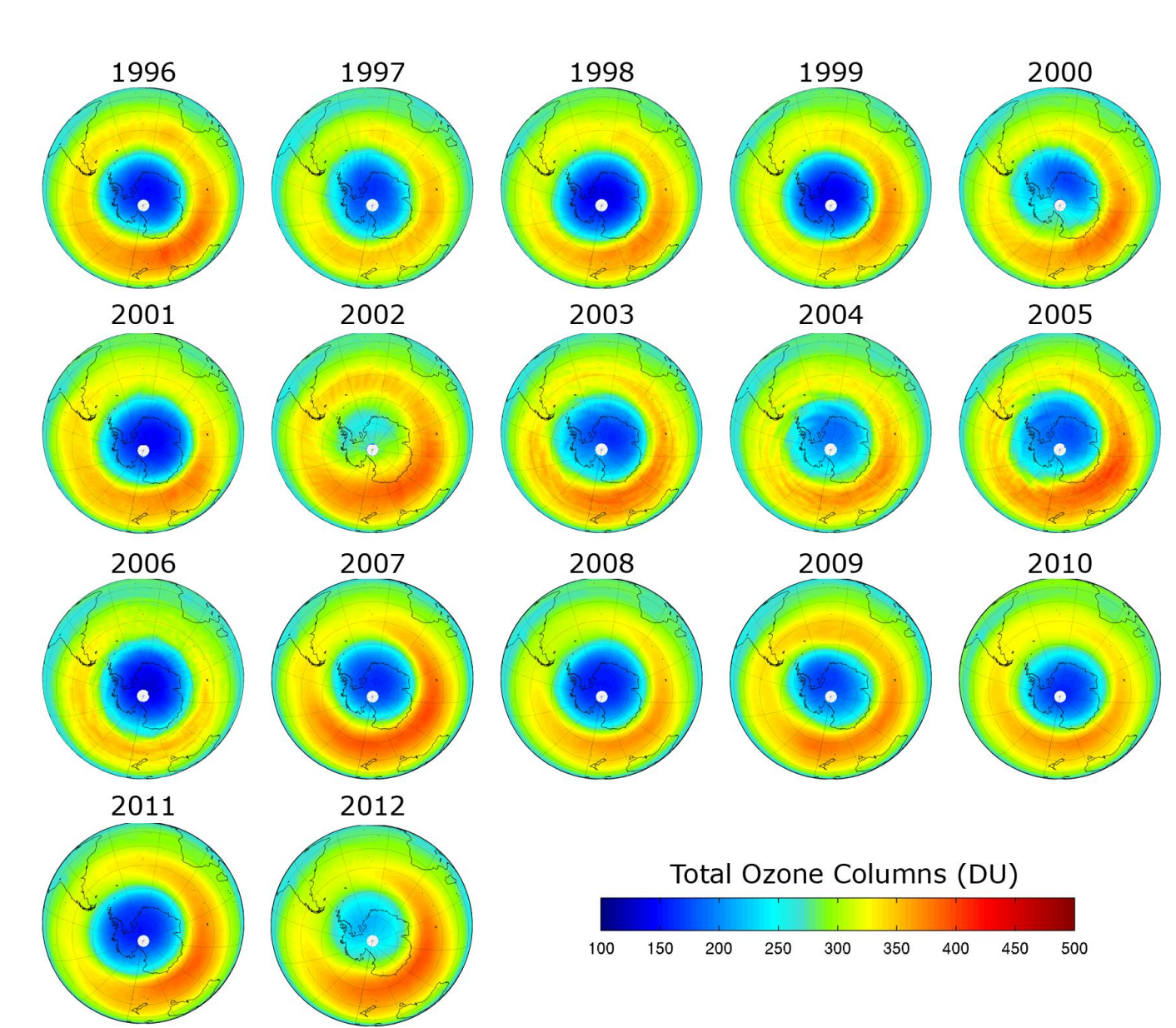
- **Direct fitting** of measured back-scattered radiances from nadir UV satellite instruments (GOME, SCIAMACHY, GOME-2) using on-line spectral simulations.
- Simultaneous **inversion of the ozone column, effective temperature and albedo** of the effective scene.
- Simulated radiances and total ozone, temperature and albedo weighting functions calculated «on-the-fly» at all wavelengths with **performance-optimized LIDORT** radiative transfer (RT) tools based on principal components analysis².
- Atmospheric polarization accounted for through correction factors applied to simulated radiances.
- **Semi-empirical Ring correction** to correct for the filling-in of the Fraunhofer and molecular lines in the measured spectra.
- **A priori O₃ profiles** prescribed using the total column-classified climatology **TOMSv8**³. The **tropospheric part** of the profile is scaled in order to match tropospheric columns from the **OMI/MLS climatology**⁴.
- Temperature-dependent O₃ absorption cross-sections from Brion, Malicet, Daumont et al.⁵
- Fitting window: **325.0 - 335.0 nm**

¹ Van Roozendaal et al., JGR, 2012; ² Spurr et al., submitted to JQSRT; ³ Mc Peters et al., JGR, 2007; ⁴ Ziemke et al., ACP, 2011; ⁵ Malicet et al., J. Atmos. Chem., 1995.

Total O₃ zonal means and total O₃ anomaly measured by GOME, SCIAMACHY and GOME-2

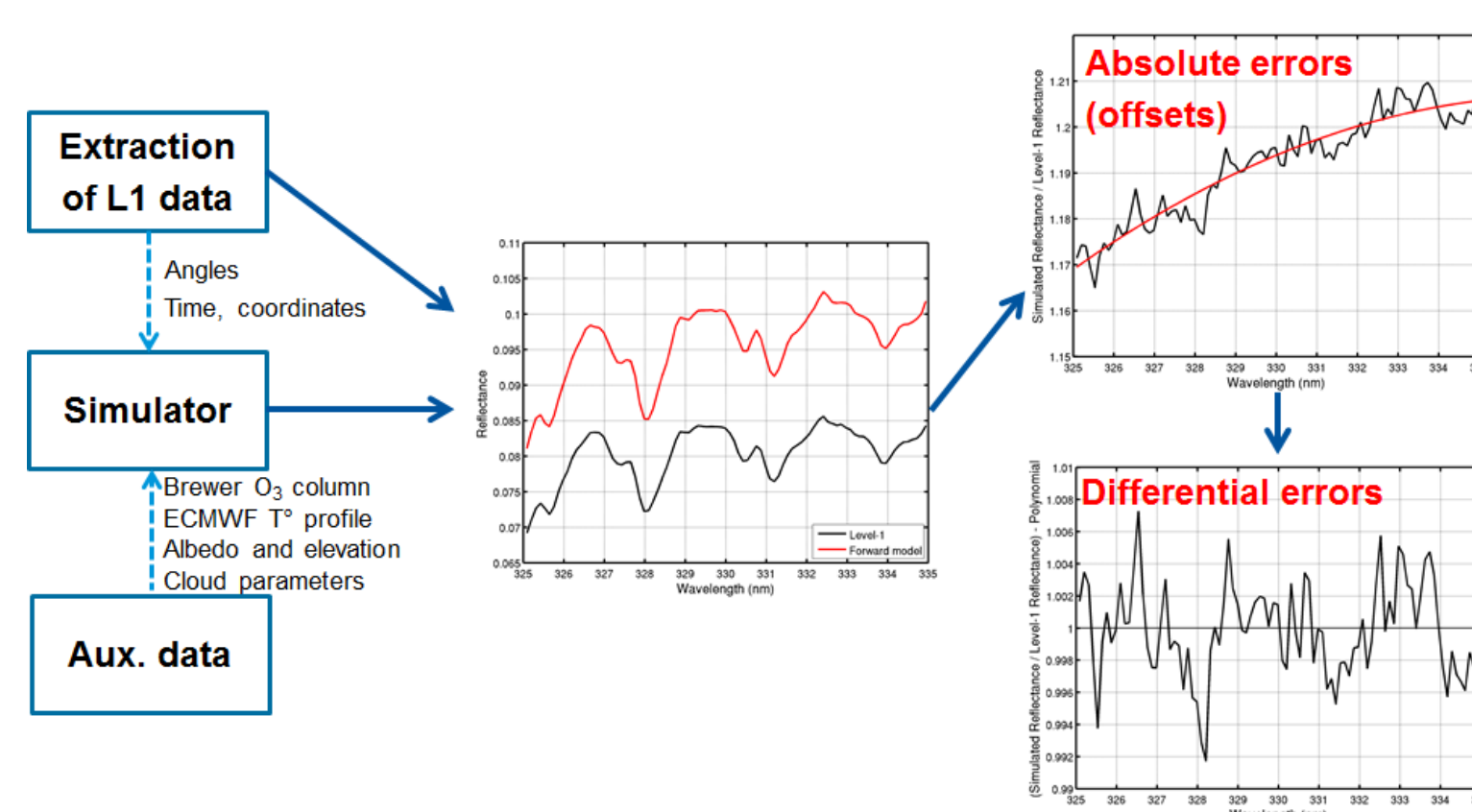


Southern pole O₃ holes seen by GOME, SCIAMACHY and GOME-2 from 1996 to 2012

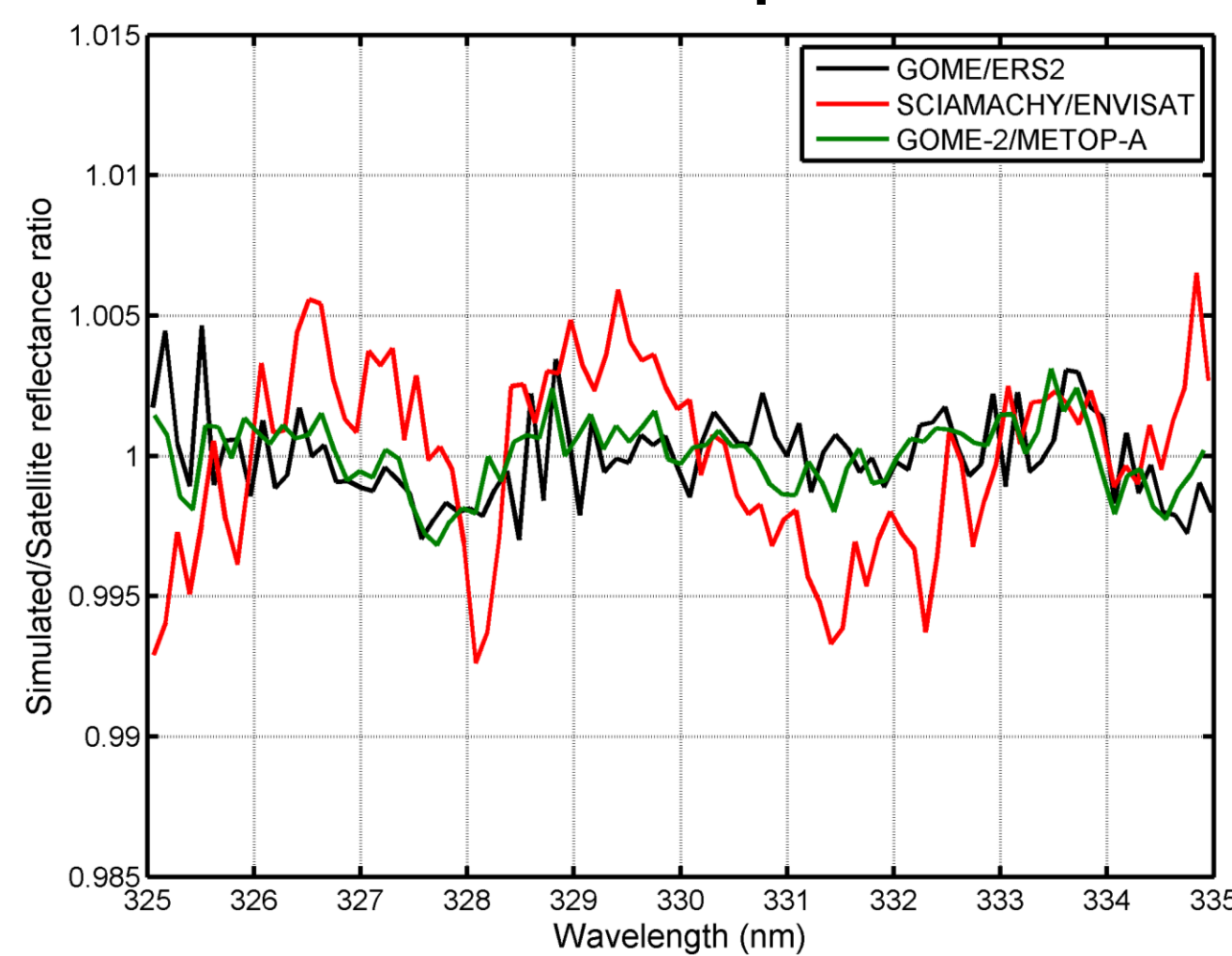


Soft calibration of measured reflectances

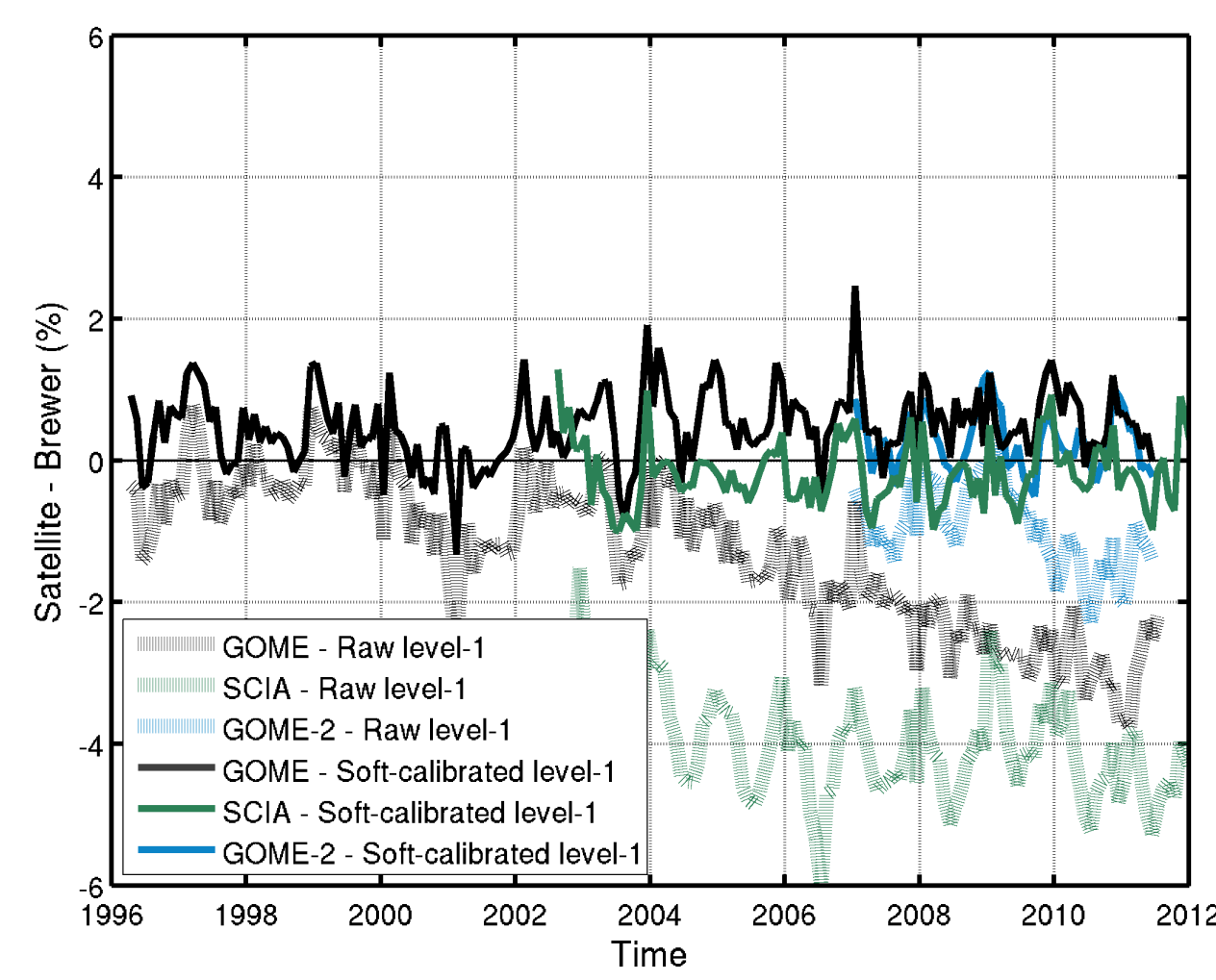
- Inconsistencies between different level-2 total O₃ data sets partly originate from calibration limitations (including instrumental degradation).
- Soft-calibration principle: Identification of artificial structures in the level-1 spectra by comparing measured to simulated reflectances. Once these structures identified and their dependencies characterized, the spectra can be corrected, bringing the inter-sensor consistency at the sub-percent level for most conditions.



Examples of differential structures in the SCIAMACHY spectra

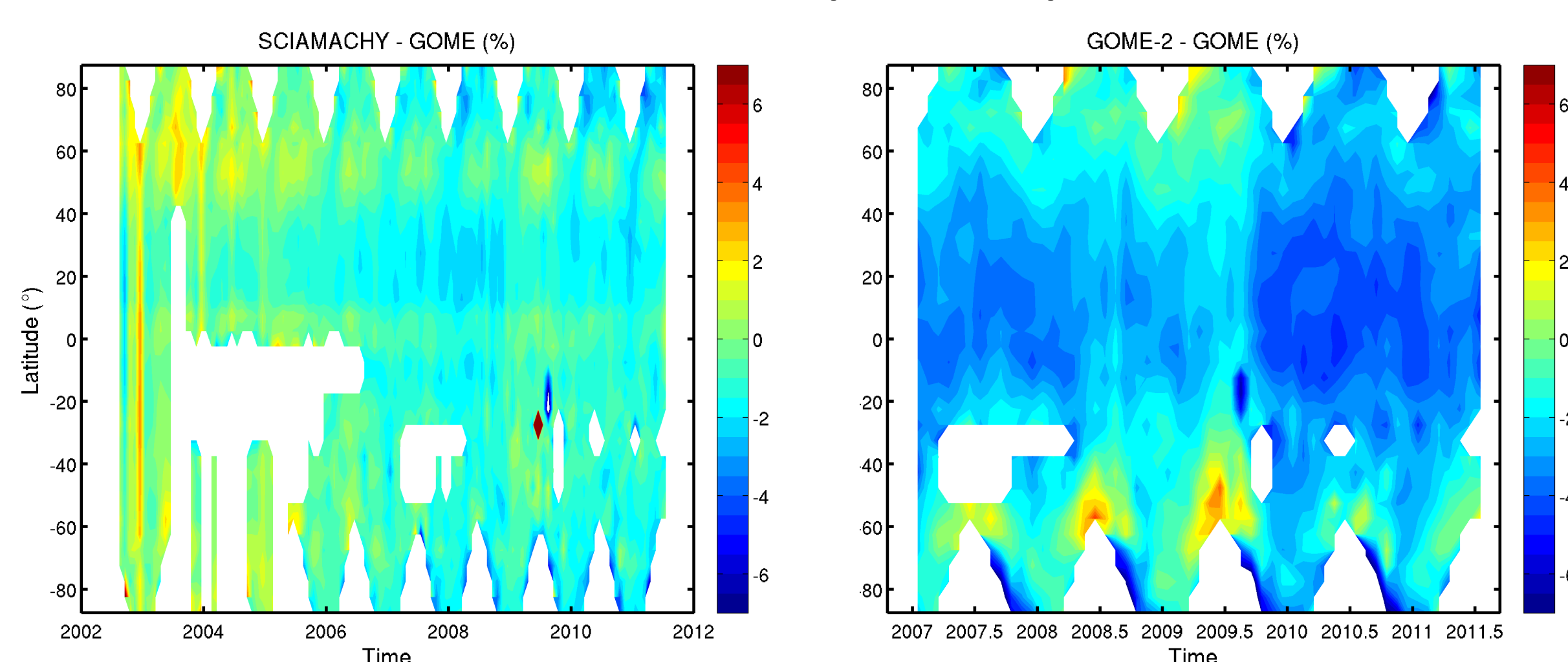


Satellite - Brewer differences at mid-latitudes stations

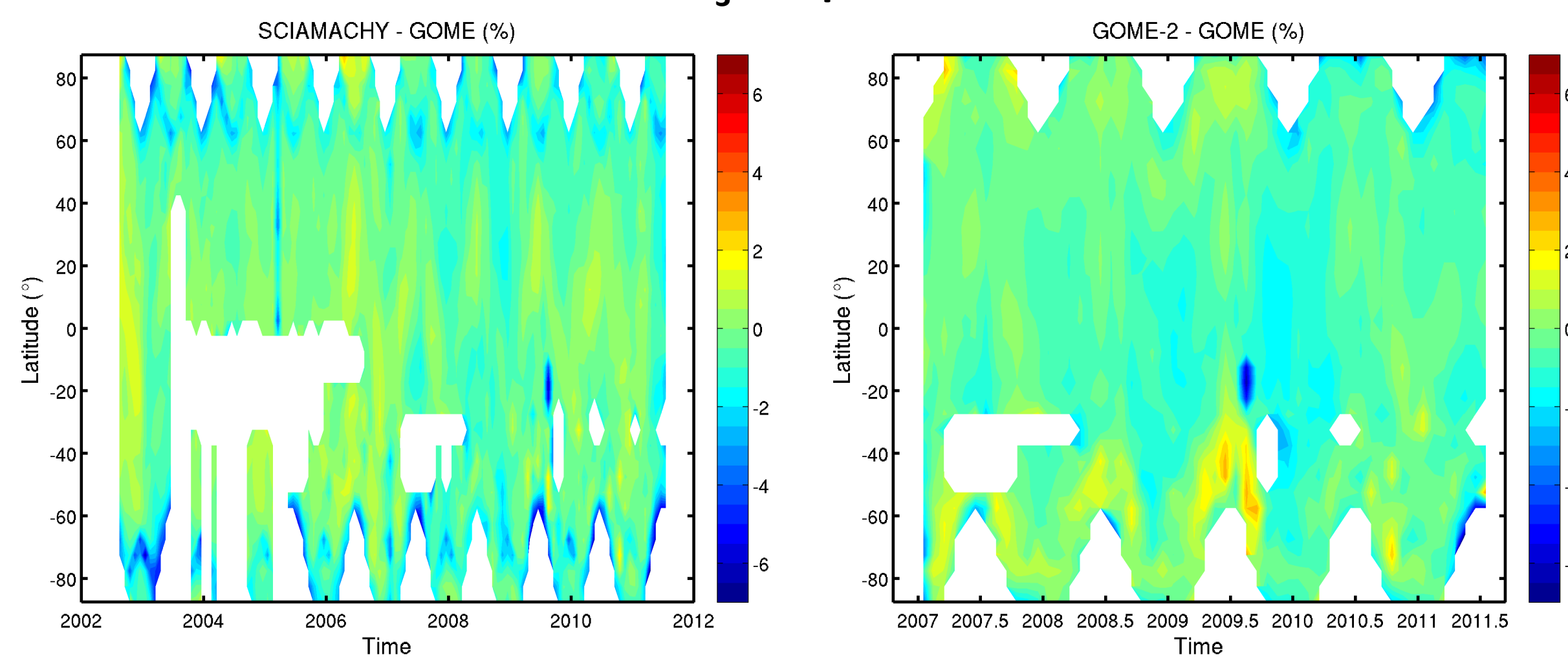


Inter-sensor consistency

ESA/EUMETSAT operational products



O₃-CCI products

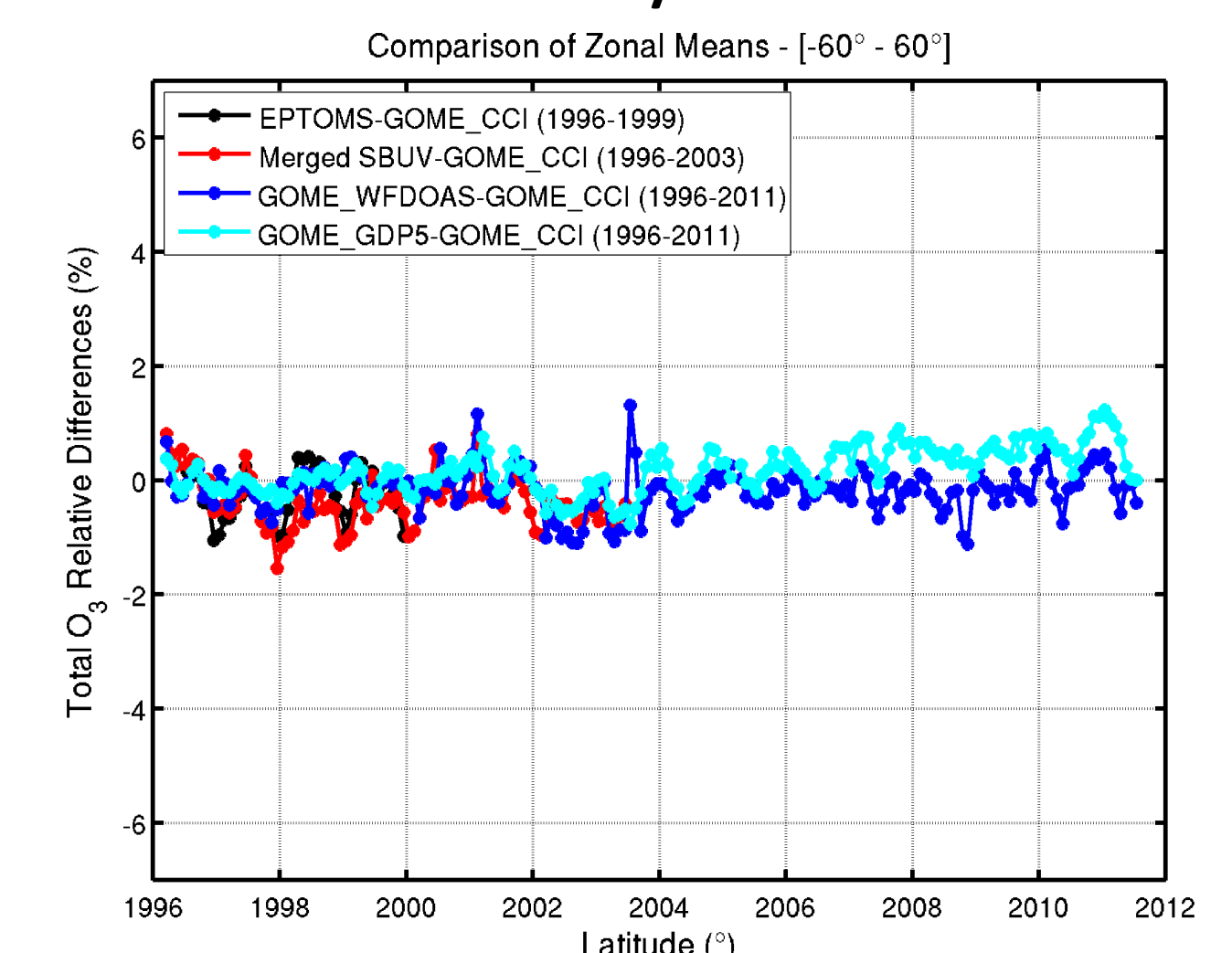


Comparisons with independent satellite data sets

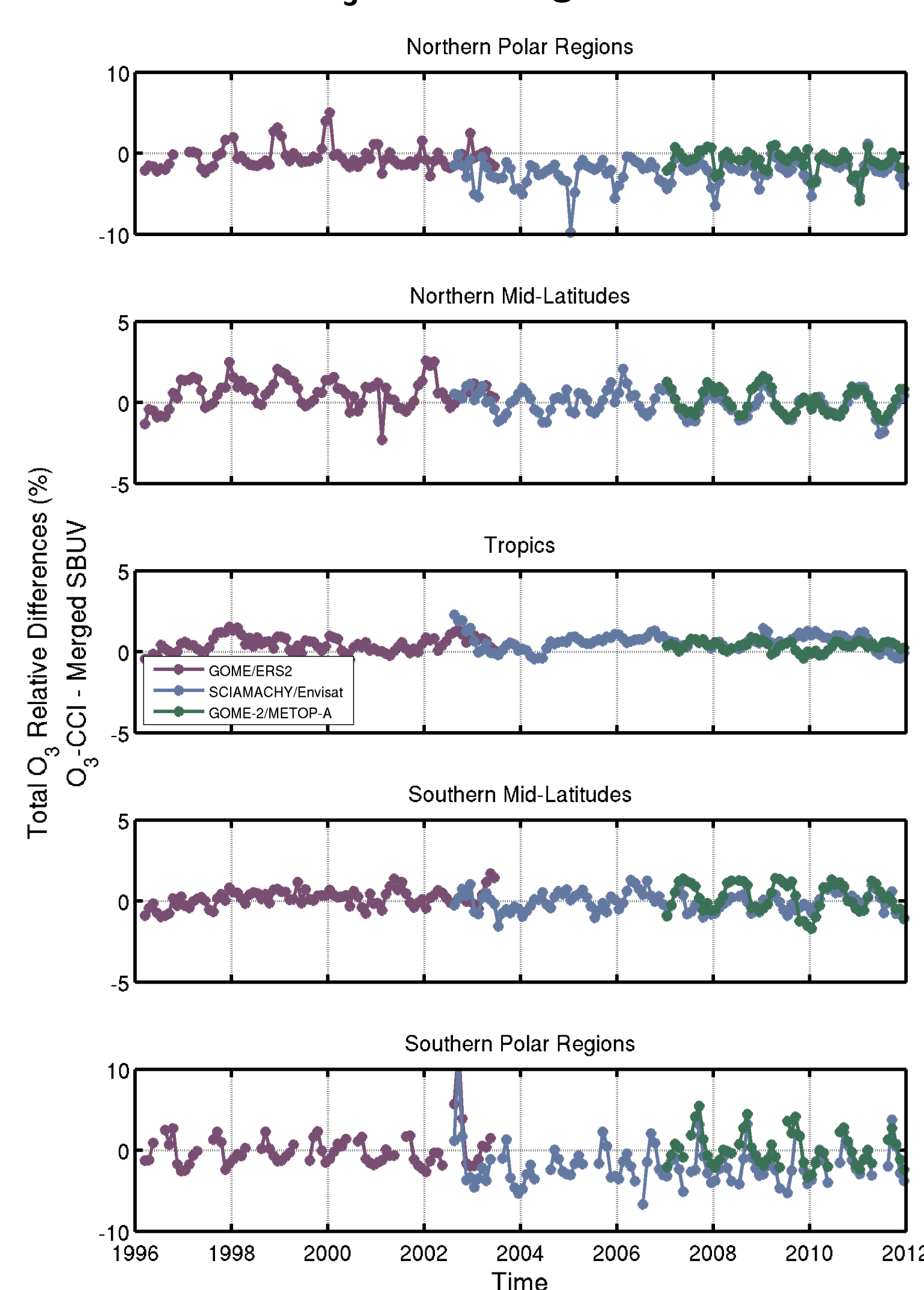
List of products

Sensor	Algorithm	
GOME	ESA/GDP5.0	IUP/WFDOAS
SCIAMACHY	ESA/SGP5.02	IUP/WFDOAS
GOME-2	EUMETSAT/GDP4.6	IUP/WFDOAS
EP_TOMS	NASA/TOMS	
OMI	NASA/TOMS	
SBUV	NASA/SBUV	

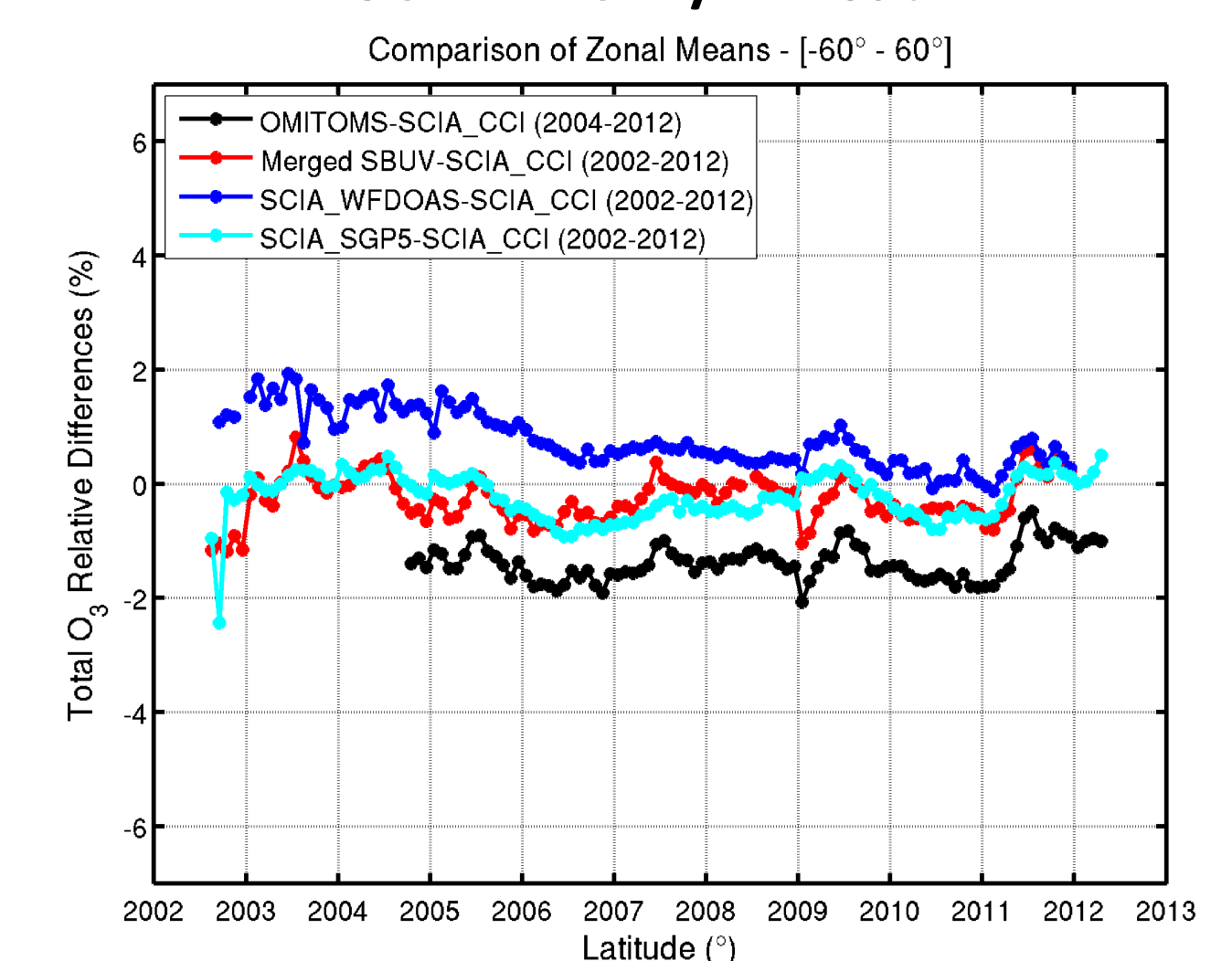
GOME/ERS-2



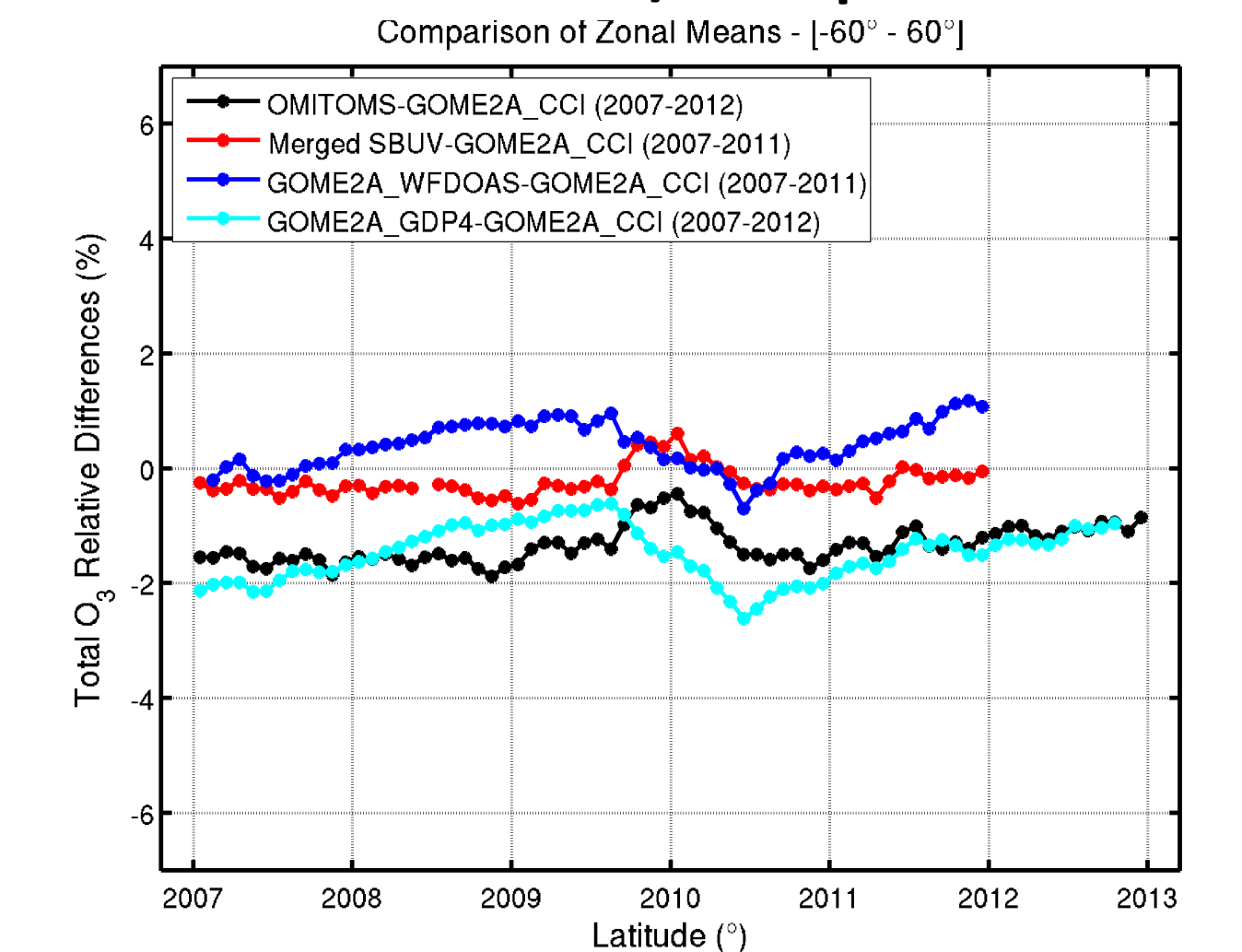
O₃-CCI - Merged SBUV



SCIAMACHY/Envisat



GOME-2/Metop-A



Conclusions

- In the framework of the ESA Ozone_cci project, improved level-2 total ozone data sets from GOME, SCIAMACHY and GOME-2 have been recently reprocessed using the prototype algorithm GODFIT. These data sets are publicly available via the website www.esa-ozone-cci.org
- The soft-calibration of the measured reflectances contributes to significantly improve the inter-sensor consistency, making this new record suitable for climate applications.
- Comparisons with other satellite products show an overall good consistency between the different data sets with mean relative differences in the range of $\pm 2\%$ at low and mid-latitudes. At high latitudes, the differences are larger and generally within $\pm 5\%$.
- These inter-comparisons also show that the CCI SCIAMACHY and GOME-2 data sets are characterized by an enhanced time stability, which results from the soft-calibration scheme reducing the impact of instrumental degradation and/or calibration limitations. This is particularly clear when looking at the differences with the merged US-standard SBUV data set.
- A demonstration merged data set based on these three sensors is currently under construction and will be made available on the Ozone_cci website in a few weeks.