DOAS retrieval of Glyoxal from space

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Glyoxal ($C_2H_2O_2$) is the smallest α-dicarbonyl. It is released by several processes, e.g. biomass burning, fermentation and industrial processes. In addition, $C_2H_2O_2$ is generally formed by the oxidation of (anthropogenic and biogenic) VOCs (Volkamer et al., 2001). Hence Glyoxal serves as a novel indicator for fast VOC chemistry (Volkamer et al., 2005a).

Glyoxal has characteristic absorption bands in the blue spectral range (see Fig. 1), allowing remote sensing by Differential Optical Absorption Spectroscopy ***DOAS***.

Ground based DOAS measurements of Glyoxal have been successfully performed e.g. in Mexico City (Volkamer et al., 2005a). From space, Glyoxal detection has recently been reported using data from the OMI satellite instrument (Kurosu et al., 2005) and SCIAMACHY (Beirle et al., 2006; Wittrock et al., 2006).

The SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY ***SCIAMACHY*** on the ESA satellite ENVISAT allows the global retrieval of trace gas cloumn densities of several molecules having absorbing features in the UV/Vis spectral range like e.g. O_3, NO_2, SO_2 or Formaldehyde. Now Glyoxal is a further trace gas being detectable from space, holding valuable information on fast VOC chemistry.

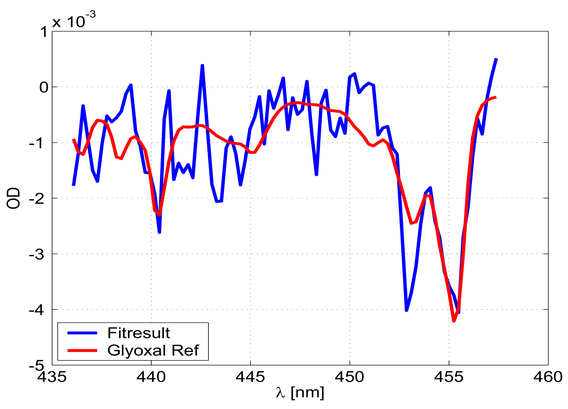

Fig. 1: *Fit example: SCIAMACHY overpass over LA on 30 Sep 2003. The earthshine spectrum from the neighbouring northerly pixel was used as reference. The Glyoxal cross section was taken from Volkamer et al. (2005b).*

For our ***analysis***, we use the spectral range 436.1 - 457.4 nm, corresponding to SCIAMACHY pixels 51-140 in channel 3, cluster 15. Fig. 1 shows an example of the Glyoxal fit (with earthshine reference) for an overpass over Los Angeles.

Using the solar reference, the fit quality suffers from artificial spectral features due to the diffuser plate, etalon structures, and calibration, leading to structured residuals and offsets in the resulting slant column density (SCD). Therefore, the resulting Glyoxal SCDs are normalized with respect to the Sahara where a zero level was assumed.

Over oceans, the fit does not work well, probably caused by spectral structures of liquid water and/or organic matter (phytoplankton) as well as inelastic scattering in liquid water ("Ring effect"), leading to negative SCDs.

Fig. 2 shows the resulting mean Glyoxal SCD for 2003-2005. So far, no further conversion to vertical column densities (VCDs) has been applied.

Applying a cloud filter does not change the observed patterns, but leads to increased noise and is therefore omitted yet.

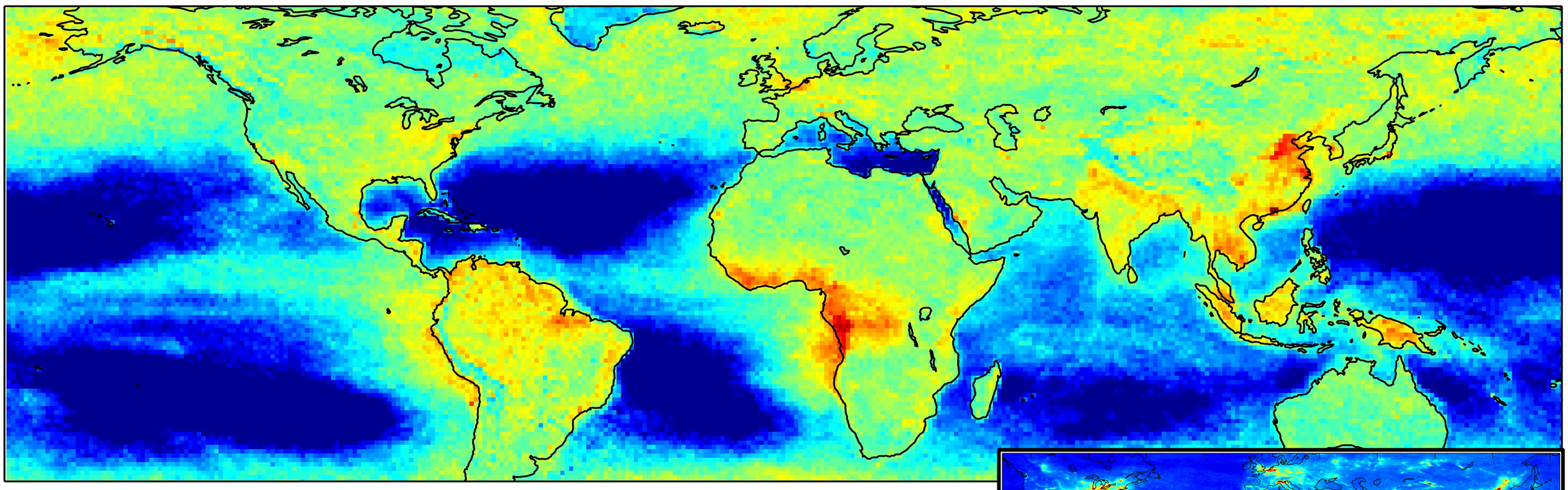

Fig. 2: ***Mean Glyoxal SCD 2003-2005.*** *(10^{15} molec/cm^2)*

In the mean Glyoxal SCD composite (Fig. 2), several **anthropogenic sources** show up **(1)**.

Furthermore, Glyoxal due to **biomass burning** can be identified **(2)**.

Also **biogenic emissions** can be observed, even over some **oceanic regions (3)**.

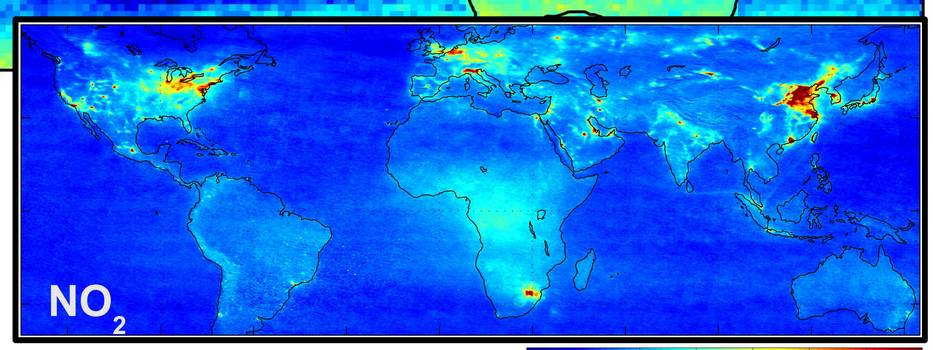

Fig. 3: ***Mean tropospheric NO_2 VCD 2003-2004*** *(Beirle, 2004)*

1. Anthropogenic sources

Several **Glyoxal hotspots** show up over large cities like LA or Hongkong where also very high NO_2 VCDs are observed (small images).
This coincidence cannot be explained by a spectral interference! (Compare Fig. 6)

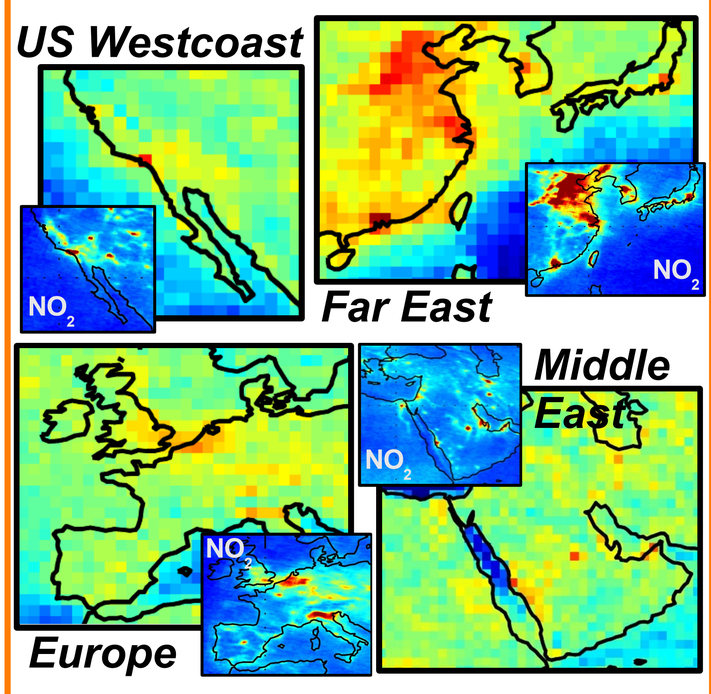

Fig. 4: Zoom of Figs 2&3 for some selected regions showing enhanced Glyoxal SCDs due to anthropogenic emissions. Colorbars as in Figs 2&3. For the Midddle East, the Glyoxal mean for 2003 is taken.

2. Biomass burning

Fig. 5 displays mean monthly Glyoxal SCDs compared to the respective ATSR fire counts over South America, indicating enhanced Glyoxal over biomass burning regions.

A direct coincidence of ATSR fire counts, enhanced tropospheric NO_2 and Glyoxal SCDs was observed during the disastrous fire storm on 18 Jan 2003 in southeast Australia (Fig. 6).

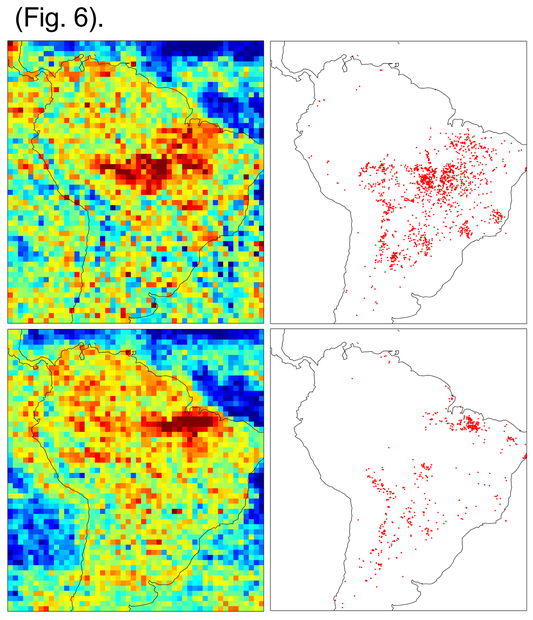

Fig. 5: Monthly mean Glyoxal SCD (left) and accumulated ATSR fire counts (right) for September (upper row) and November (lower row) 2003 over South America.

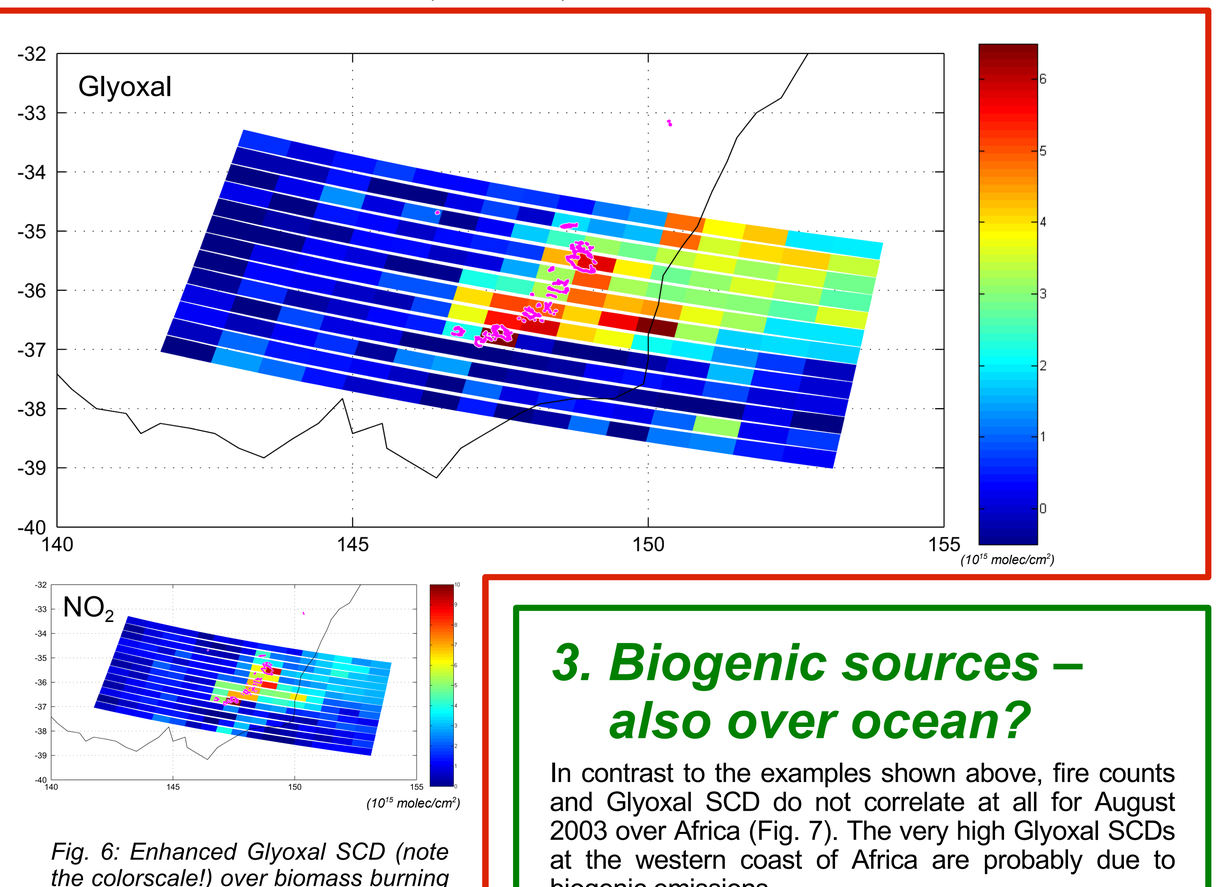

Fig. 6: Enhanced Glyoxal SCD (note the colorscale!) over biomass burning (magenta dots mark ATSR fire counts, total ~1000) in southeast Australia on 18 Jan 2003. The small figure shows the corresponding tropospheric NO_2 SCD.
Note that NO_2 and Glyoxal are not throughout correlated, excluding spectral interference.

3. Biogenic sources – also over ocean?

In contrast to the examples shown above, fire counts and Glyoxal SCD do not correlate at all for August 2003 over Africa (Fig. 7). The very high Glyoxal SCDs at the western coast of Africa are probably due to biogenic emissions.
Generally, high Glyoxal SCDs are observed over the tropical ocean west from Africa and South America (Figs. 2, 7). Due to the very short lifetime of Glyoxal this may indicate direct VOC emissions over these bioactive oceanic regions.

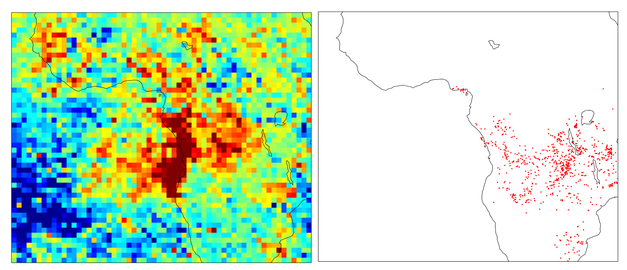

Fig. 7: Monthly mean Glyoxal SCD (left) and accumulated ATSR fire counts (right) for August 2003 over central Africa.

Acknowledgement

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References

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