BIOGEOSCIENCE REVIEW OF SCIAMACHY RESULTS

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1. ABSTRACT

SCIAMACHY as an A.O. instrument is followed by science teams in the three participating counties: Germany with IFE at the University of Bremen and several institutions including the University of Heidelberg and MPI Mainz, in the Netherlands, KNMI and SRON lead the Dutch scientific team while in Belgium, the Belgian Institute for Space Aeronomy leads a Belgian science team.
The main objective of the instrument was to give a complete mapping of stratospheric ozone of which the role as a UV-B filter is essential to sustained life on the earth's surface. SCIAMACHY has also a tropospheric sounding capability and is thus to follow the chemical weather of the global troposphere.
The results obtained since ENVISAT launch have shown various surprising influences of biological processes in the atmosphere including new biogenic sources of trace gases relevant to ozone chemistry in both the troposphere and stratosphere.
Biogeosciences aspect are as relevant to atmospheric science as they are to earth science as important sources of methane, nitrous oxide, formaldehyde, glyoxal and other products are mainly biological.

2. INTRODUCTION: WHAT ARE BIOGEOSCIENCES?

Biogeosciences were already present at the onset of atmospheric chemistry and physics when methane was discovered in marshes in the late eighteenth century. Its importance increased with the discovery of methane and nitrous oxides in the clean atmosphere by Adel in 1938 and Migeotte in 1948. Bates and Witherspoon (1952) reviewed these early observations as well as the sinks and sources of trace gases and came already to the conclusion that biological sources were important in the balance of most gases present in the natural atmosphere.
Biogeosciences can be defined as life phenomena from geophysical causes and as geophysical phenomena from biological causes. In the case of atmospheric sciences, this is also effective, for example, stratospheric ozone controls surface UV and can be affected by nitrous oxide produced in oxygen poor soils. Life is of course essentially represented by the land surface, ocean and hydrosphere but endolithic life is more and more considered. Airborne life has been demonstrated up to the stratosphere but it is negligible in terms of balance and would become important only if the transport of pathogen could be put in evidence.

3. SCIAMACHY and BIOGEOSCIENCE

At its early design, it was decided that the SCIAMACHY instrument in its nadir mode would observe tropospheric columns of trace gases, as well as stratospheric and mesospheric gases. The main drive of the programme was the understanding of ozone chemistry in the entire atmosphere. Ozone is in itself a biologically important gas, it is produced in the stratosphere by the photo-dissociation of biologically produced oxygen. A reduction in stratospheric ozone related to catalytic cycles introduced by nitric oxide, chlorine or bromine atoms would lead to an increase of surface UV and would stress the majority of surface life forms.

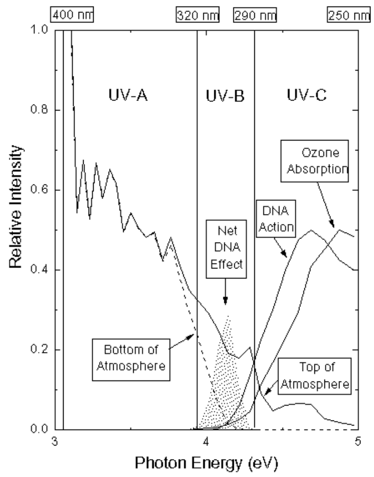

Figure 1: Definition of UV effective radiation (American Medical Association document). Stratospheric ozone filters the entire UV-C and a large part of UV-B.

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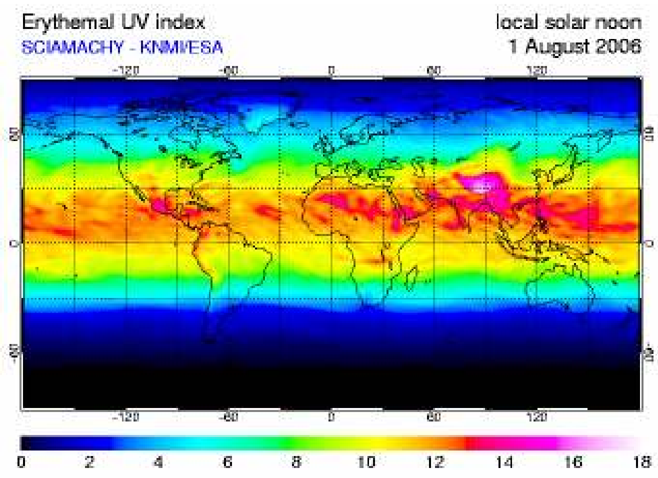

Figure 2: Erythemal UV index determined from the SCIAMACHY ozone retrieval as an operational product in the frame of the ESA TEMIS project.(KNMI document)

Tropospheric ozone is a toxic and stresses most plants, together with other air quality factors, it is a cause of respiratory diseases in man. The same thing could be said of other SCIAMACHY air quality products as tropospheric nitrogen dioxide and sulphur dioxide. Tropospheric ozone is produced photochemically from precursors which are essentially the products of industrial activity and the combustion of fossil fuels. Natural volatile organics are not sufficient to produce tropospheric ozone in the absence of "man introduced" precursors. These gases deserve more to figure in an air-quality review of SCIAMACHY results.

4. INFRARED GASES.

The most important biogenic gases have all important signatures in the infrared, carbon monoxide, carbon dioxide, nitrous oxide and methane are even almost impossible to measure in the UV and visible. At the SCIAMACHY design, it was at the insistence of Pr. P. Crutzen that infrared channels were added in order to observe the tropospheric columns of these gases.

At the time (1998), the problem of climate was already known but seen as a lesser priority than the subjects covered by the just signed Montréal protocol. SCIAMACHY proved remarkable in the sense that its validation triggered the survival of the greenhouse gases monitoring network.

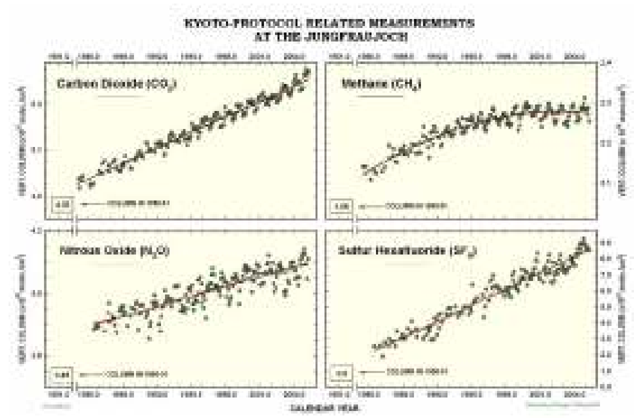

Figure 3: greenhouse gases trends measured at the Junfraujoch in the frame of the SCIAMACHY validation (document University of Liège, IASB-BIRA, Demoulin, 2007)

Figure 4: Pr. Paul Crutzen (ESA document), Paul Crutzen wanted the SCIAMACHY instrument to be able to survey most of atmospheric chemistry.

The design of the infrared channels in the weight and signal constrains of the instrument was very difficult but was finally successful, it should be reminded that some detectors had to be specified "state of the art" as the suppliers could not guarantee that they would meet an explicit requirement.

The interpretation of the infrared channels on the oceans is still difficult due to low ocean reflectivity, aerosol reflectivity problems have some time to be corrected but the results are now reaching validation.

Methane is quite exemplary in this respect as the current interpretation shows clearly biogenic natural sources, sources associated with rice agriculture and sources associated with fossil fuels extraction.

The average of carbon dioxide reflects the production by biomass burning. The same could be said of CO.

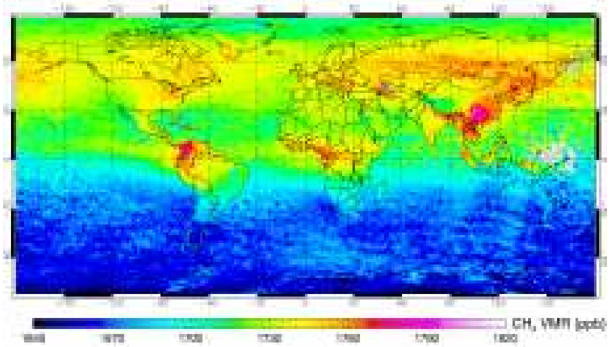

Figure 5: Volume mixing ratio of methane, averaged on 2003 and 2004 (Frankenberg , 2007).

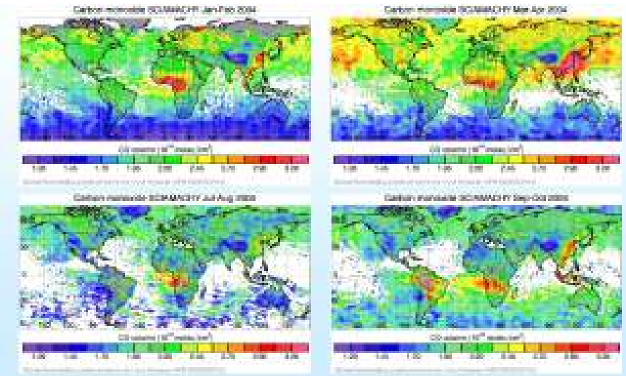

Figure 6: CO (Buchwitz, 2007), again the combination of biomass burning and industrial sources is clearly seen.

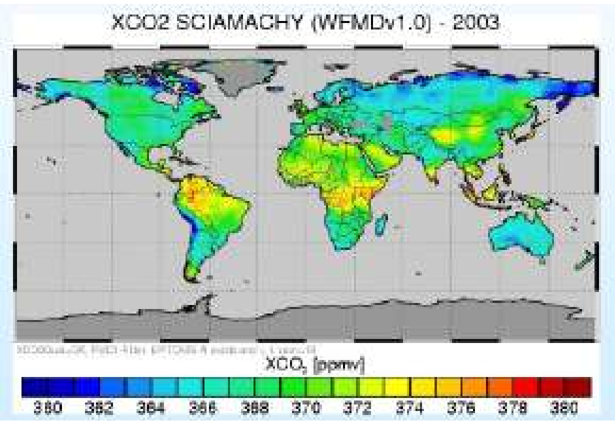

Figure 7: SCIAMACHY carbon dioxide, average over 2003 (Buchwitz, 2007).

5. SURFACE CAPABILITY

SCIAMACHY has demonstrated a capability of observing phytoplankton in the visible channels.

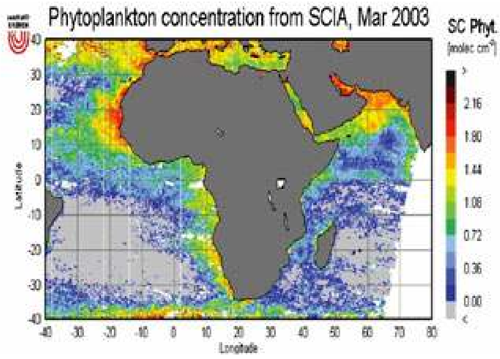

Figure 8: observations of phytoplankton (A. Bracher et al, 2005)

SCIAMACHY has also an imaging capability through its PMD (Polarisation Measuring Device) channel which can be use to produce true colour images of the surface. The data series acquired since 2002 could be used to observe the context evolutions of MERIS observations as for example the greening trend of Siberia.

6. UV-VISIBLE BIOGENIC GASES.

The UV-visible allows adequate observations of formaldehyde which were already performed during the flight of GOME.

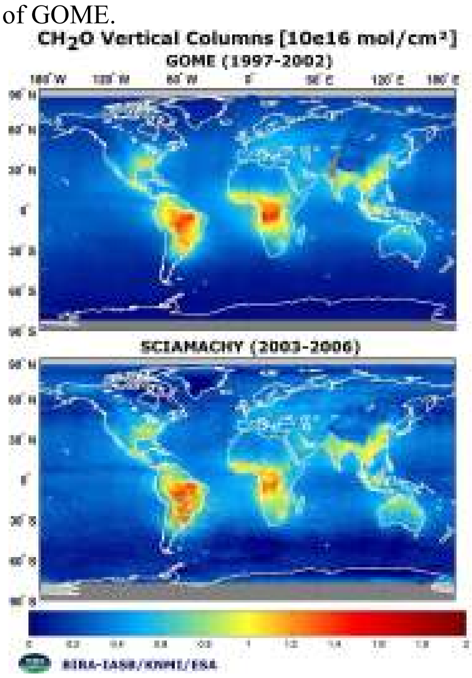

Figure 9: observation of formaldehyde showing the influence of biomass burning. (Desmedt, 2007).

Now recently, a much less abundant constituent: glyoxal could be studied in the SCIAMACHY signal.

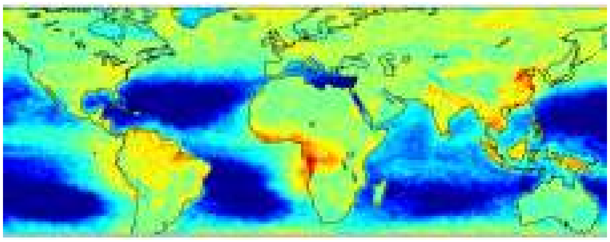

Figure 10: Glyoxal yearly average, concentrations are about 20 times lower than formaldehyde, (Marbach and Beirle, 2007 MPI Mainz.)

7. CONCLUSIONS

SCIAMACHY has demonstrated its capability to be used as a basis for geosciences studies. This rapid review of some results has stressed the importance of biomass burning and the importance of studying its global impacts. Biomass burning is clearly man induced in most cases and thus action could be possible.

Fig. 11: ISS photo showing biomass burning in central Africa on May 16, 2002. (NASA document).

Biomass burning is not covered by any of the treaties, it disappeared in Europe at the beginning of the 20th century in relation with the introduction of fertilisers and the practice of culture rotation.

The SCIAMACHY signals of the entire SCIAMACHY mission constitute a mine on global change which will have to be exploited long after, sometime in the next decade, ENVISAT will be decommissioned.

8. ACKNOWLEGEMENTS.

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I would like to extend special thanks to Albert Goede who left the position of Dutch co-Pi in 2006 for his constant interest in the societal aspects of this scientific project.

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