Summary of the first ACSO plenum meeting

11-13 May, 2009, WMO, Geneva

by Johannes Orphal, Johannes Staehelin and Johanna Tamminen

1. Work of ACSO

The committee "ACSO" ("Absorption Cross Sections of Ozone") established in spring 2009 is a joint *ad hoc* commission of the Scientific Advisory Group (SAG) of the Global Atmosphere Watch (GAW) of the World Meteorological Organization (WMO) and the International Ozone Commission IO3C) of the International Association of Meteorology and Atmospheric Sciences (IAMAS).

The mandated tasks of ACSO include:
- **Review** of presently available literature of ozone absorption cross sections and their temperature dependencies covering all relevant atmospheric temperatures; first priority is the wavelength range of 300-350 nm ("Huggins" bands) with possible extension to ultraviolet ("Hartley" band), visible ("Chappuis" band and "Wulf" bands) and IR wavelengths.
- Determine the **impact of changing** the reference ozone absorption cross sections for all of the commonly used (both ground-based and satellite) atmospheric ozone monitoring instruments. This part of the study shall include the impact on the consistency of the ozone records from instruments in the world-wide monitoring of ozone and the impact of the implementation on the groups responsible for the instruments.
- **Recommend** whether a change needs to be be made to the presently used WMO/IO3C standard ozone absorption cross section data. (The presently used standard is based on Bass and Paur, 1985).
- **If** a change is recommended, then **provide guidelines** and a precise time-line for implementing new absorption cross sections, separately for each instrument type.
- The findings including recommendations of the Expert Team need to be documented in a report that shall be approved by the GAW-SAG and the IAMAS-IO3C.

The recommendations are to be discussed with the community of the involved experts. The work will be finished within two years after the first meeting in 2009.

The ACSO Expert Team, which is led by Prof. Dr. Johannes Orphal (Karlsruhe) was established in 2009 with 27 members (see Appendix 1). Representatives from NASA, ESA, SAG-ozone, WMO, IO3C and IGACO-O3/UV are among the participants as well as laboratory experts and algorithm specialists of several ground-based and satellite instruments that use the Huggins bands for atmospheric ozone measurements. The kick-off meeting was arranged in combination with the Ozone Theme Meeting. A related activity was defined within IGACO-Ozone/UV (igaco-O3.fmi.fi).

2. *Main results of "Ozone Theme Meeting"*

Ozone absorption cross sections measured by Bass and Paur (BP, 1985) are presently used as standard for retrieval of many types of atmospheric ozone measurements. Recently it was found, that the laboratory data published by the French group Daumont-Brion-Malicet (DBM, published during the 1990s) are more suitable for applications in satellite and some ground-based retrievals.

The first meeting of ACSO was hosted by WMO, Geneva, 11-13 May, 2009 (second Ozone Theme Meeting). The topic was focused particularly on the use of different ozone absorption cross sections, mainly in the Huggins band. The meeting consisted of four sessions:

(1) general introduction
(2) laboratory measurements of cross sections
(3) impact of changing ozone cross sections on ground-based instruments
(4) impact of changing ozone cross sections on satellite instruments.

The meeting was very successful and the discussion was active. Alltogether 19 talks on cross sections were presented and they can be found in the WWW page: http://igaco-o3.fmi.fi/ACSO.

The following important findings were discussed:

- It is not always perfectly clear which set of ozone absorption cross sections and what kind of temperature dependence are used by different teams/instruments. In particular, several different data sets are used for the standard BP cross sections (with differences in shift, squeeze, resolution, etc) and also for the DBM data. Therefore, a publicly accessible database needs to be created in order to make sure that the individual groups use the same ozone cross sections (including temperature dependencies) and also traceability of earlier scientific studies based on different sets of cross sections.
- The temperature dependence is considered by many groups to be more reliable in the DBM than in the BP set of ozone cross sections.
- Changing from the Bass and Paur (BP) cross sections to the Daumont-Brion-Malicet (DBM) cross sections will have rather different impacts depending on the instruments:
  (a) Brewers show strong dependence. Slightly mixed results by various teams.
  (b) Dobsons show only minor dependence. Temperature dependence has stronger impact.
  (c) OMI DOAS retrieval shows only small impact, ~1-2 DU differences.
  (d) OMI TOMS algorithm shows larger, 1-1.5% differences.
  (e) OMI profile algorithm: strong impact, differences up to 10-15% at low altitudes.
  (f) –SBUV profile algorithm: DBM lower few percent on the middle stratosphere and few percent higher in lower stratosphere / troposphere.
  (g) Lidars: dominant error originates from the temperature dependence.

  Note that the differences also depend on atmospheric (e.g. seasonal) and retrieval (e.g. solar zenith angle) conditions. Note also that in several cases other instrumental effects

(e.g. straylight, use of different instrumental line shapes i.e. “slit functions”) lead to equal or even higher differences in the retrieved ozone concentrations or columns.

- Residual analysis: Which cross sections are ‘better’ can be answered by performing residual analysis.
  (a) Residual analysis for TOMS retrievals shows better agreement with DBM than BP.
  (b) OMI DOAS residual analysis is slightly better with BP.
  (c) Residual analysis of U.S. OMI profile retrieval shows better agreement with DBM than with BP. Dutch OMI profile retrieval shows mixed results (limited data set: DBM better at tropics and high lat, BP better at 30N). This clearly demonstrates the further sensitivity of the results on the radiative transfer algorithms used.
  (d) Residual analysis of comparing BP, DBM and GOME FM in SCIAMACHY retrievals shows better agreement with DBM than with BP. Using the GOME FM cross sections is close to DBM but slightly worse. Results are consistent at all solar zenith angles.
  (e) Residual analysis has been done for several satellite instruments but it is also needed for ground based instruments.
- Effective temperature: in some retrieval algorithms the so called *effective temperature* is fitted simultaneously with the ozone. The agreement of the fitted effective temperature with independently measured corresponding effective temperature can be used as an indicator of successful retrieval (and thus agreement with cross sections).

NASA and ESA (GOME, SCIAMACHY, GOME-2) are most probably going to change from BP to DBM because of the smaller residuals and internal consistency of the ozone data products.
It was noted that it is very important to have consistent cross sections covering a large wavelength range (including the Hartley and Chappuis bands), sufficiently high spectral resolution and well-characterized slit function characterization at several temperatures (including also lower T than presently available).

There is an urgent demand to intercompare by new laboratory studies the ozone absorption cross sections in different wavelength regions (UV, visible, IR) which is important to harmonize atmospheric ozone measurements made by different instruments. It was agreed, that the problems concerning measurements in the Huggins band have the highest priority within the work of ACSO at the present time.

Further laboratory measurements of ozone cross sections in the Huggins band, particularly including temperature dependencies, are very desirable. However, they should not delay other studies related to atmospheric ozone measurements.

It appears that the community engaged in atmospheric ozone measurements should first focus on the question whether it is justified to recommend DBM instead of BP as new standard in the atmospheric ozone community.

3. Planning: Next steps

The interested science community will meet again to discuss the progress in a similar type of meeting which is scheduled to take place again in the form of the next "Ozone Theme Meeting" at Geneva. Such a meeting should preferably take place in spring 2010. The main issue will be to decide whether a change from BP to BDM cross sections is justified implying that experts looking at individual instruments are expected to present a statement regarding this key question. It is also important to have until then a very clear strategy how to implement this change and what the impact of this change is on ozone records and different ozone data products.

Until the meeting the work is therefore planned to proceed within three working groups that will mainly discuss via email.

(1) Laboratory measurements: *Coordinator:* ***J. Orphal***, other (possible) members: J. Burkholder, G. K. Moortgat, M. Weber, A. Serdyuchenko, M. van Roozendael, J. Viallon, C. Janssen, A. Chakir, A. C. Vandaele, R. Schinke, R. A. Cox, P. Kiedron, J. Hodges, M. Birk, J.-M. Flaud, A. Barbe, S. P. Sander…:

Mandate: (i) Provide a review of the available database of spectral ozone measurements in the Huggins bands, (ii) evaluate their uncertainties (including temperature dependence) and (iii) initiate and coordinate new laboratory measurements, (iv) prepare a written summary of the work to be distributed to the members of ACSO and interested scientists (deadline: end of 2009)

(2) Satellite observations: *Coordinator:* ***J. Tamminen***, other (possible) members: M. van Roozendael, C. Zehner, J. Orphal, P. Veefkind, R. McPeters, M. Weber, P. K. Bhartia, H. Worden, G. Stiller, E. Kyrölä, M. Pitts, D. Flittner, P. Schlüssel, R. Munro, M. Santee, D. Degenstein, K. V. Chance, X. Liu, R. von der A., A. Kaifel, ….

Mandate: (i) evaluate further and coordinate new retrieval studies concerning the possible shift of BP to DBM ozone cross sections regarding satellite ozone measurements; (ii) summarize the respective results and critically evaluate whether all relevant satellite instruments (making ozone measurements using the Huggins bands) are covered; (iii) prepare a written summary of the work to be distributed to the members of ACSO and interested scientists (deadline: end of 2009)

(3) Ground-based observations: Coordinators: ***J. Staehelin, S. Godin-Beekmann***, other (possible) members: B. Evans, M. van Roozendael, U. Koehler I. Petropavlovskikh, A. Redondas, J. Orphal, P. Kiedron, E. Kyrö, G. Labow, T. McElroy, G. Braathen, J. Tamminen, R. Stübi, S. McDermid, K. Vanicek, M. Gil, M. Schneider, M. de Mazière, N. Kämpfer, E. Hare, C. Zerefos, A. Bais, D. Balis, T. Koide, B. Bokjov …

Mandate: (i) evaluate further and coordinate new studies concerning the possible shift of BP to DBM ozone cross sections of ground based ozone measurements (making use of ozone absorption in the Huggins bands); (ii) summarize the respective results and critically evaluate whether all relevant ground based ozone instruments are covered; (iii) prepare a written summary of the work to be distributed to the members of ACSO and interested scientists (deadline: end of 2009)

Finally it is important to note that a dedicated WWW site has been created to document the work of the ACSO Committee has been created (http://igaco-o3.fmi.fi/ACSO) and is publicly accessible in order to provide a common basis for further discussions and studies.

Appendix 1: Members of ACSO

Orphal Johannes, chair

Bhartia PK, ex officio

Braathen Geir, ex officio

Zerefos Christos, ex officio

Tamminen Johanna, ex officio

Staehelin Johannes, ex officio

Zehner Claus, ex officio

Evans Robert, Dobson

McElroy Thomas, Brewer

Godin-Beekmann Sophie, Lidar

Bais Alkiviadis, Brewer

Petropavlovskikh Irina, Umkehr

Cox Anthony, lab/IUPAC (obs.)

Burkholder James, lab

Labow Gordon, sat. expert

van Roozendael Michel, DOAS, sat. expert

Weber Mark, sat. expert

Veefkind Pepijn, sat. expert

Kyrölä Erkki, sat. expert

Degestein Doug, sat. expert

Pitts Michael, sat. expert, Chappuis band

McPeters Richard, sat. expert

Flittner David, sat. expert

Chance Kelly, sat. expert

Balis Dimitris, satellite valid

Liu Xiong, sat. expert

Hare Ed, data, archive (WOUDC)