# Minutes of the
# 7th Atmospheric Composition Constellation Workshop (ACC-7)
# Columbia, Maryland, USA
# 21-22 June 2011

## 1.0 Executive Summary

The Committee on Earth Observation Satellites (CEOS) ACC-7 was held at the Sheraton Columbia Town Center Hotel in Columbia, Maryland, USA, on 21-22 June 2011. The Atmospheric Composition Constellation (ACC) is one of the six virtual constellations that support the overall goals of the Group on Earth Observations (GEO) and provide prototype systems supporting the implementation of the Global Earth Observing System of Systems (GEOSS). The meeting was attended by representatives from participating CEOS agencies, related universities, and supporting organizations, including the Belgian Institute for Space Aeronomy, CSA, DLR, Environment Canada, ESA, EUMETSAT, Finnish Meteorological Institute, Johns Hopkins University, NASA, NOAA, Northrop-Grumman, SPARC, University of Bremen, and University of Maryland. We are grateful to Kathy Thompson and Rose Kendall for meeting logistics. We also acknowledge the assistance of Chad Hawkins and David Stack (NASA DEVELOP program) in taking minutes during parts of the meeting.

The Workshop had three sections: 1) Status of ACC activities, (2) Next steps for the Air Quality constellation, and (3) Total ozone record harmonization. The workshop Agenda and participant list are attached to these minutes. The presentations can be found at: (http://www.ceos.org/index.php?option=com_content&view=category&layout=blog&id=53&Itemid=94

## 2.0 Workshop Highlights and Recommendations

1. Agency Tour de Table and ACC Activities

    a. Agencies activities: Progress for deploying multiple space-based platforms to measure atmospheric composition constituents in the coming decade is proceeding across all of the CEOS-member agencies that reported. Significant collaboration between space agencies on upcoming missions and those in formulation was evident.

    b. Volcanic Ash Monitoring: Recent eruptions of Icelandic volcanoes (Eyafjallajökull and Grímsvötn) have demonstrated the utility of space-based measurements of ash concentration and height in constraining forecast models and to provide early warnings (alerts) to enhance aviation safety. The basic goals of the project have been achieved and it is now an ongoing task.

    c. CEOS response to the Global Climate Observing System (GCOS) Implementation Plan: ACC members have addressed the CEOS-mandated action to contribute to the relevant action templates that will form the basis for the CEOS response to the GCOS

Satellite Supplement, providing detailed bases for what is achievable with current and planned resources. It was agreed at the meeting that actions addressing cloud and aerosol parameters will not be addressed by ACC as these issues are being covered already by ongoing activities (e.g. GEWEX) and the ACC priorities are on trace gases.

Goal: ACC membership and the extended community will review these templates and work towards completion of the task. Further progress will be assessed at the CEOS Plenary in November.

d. The Atmospheric Composition Portal (ACP): ACP is now formally under the aegis of the CEOS Working Group on Information Systems and Services (WGISS) and is requesting participation of ACC membership on its Science Advisory Group to enhance the portal's utility to the atmospheric composition community.

e. Stratospheric Processes and their Role in Climate (SPARC) activities: Representatives of the SPARC Ozone Profiles and Lifetimes of Long-Lived Stratospheric Species described these projects and potential synergies with ACC activities.

f. Ozone Research Managers (ORM) of the Vienna Convention: A presentation on the recent meeting of the ORM was made. ACC will endeavor to engage the ORM group and support its activities.

2. Air Quality Constellation

a. The position paper "A Geostationary Satellite Constellation for Observing Global Air Quality: An International Path Forward" has been completed and reviewed externally by the air quality community. It is available at http://www.ceos.org/images/ACC/AC_Geo_Position_Paper_v4.pdf. A series of recommendations were developed in the paper and these were presented at the CEOS Strategic Implementation Team (SIT-26) meeting in Frascati in May, 2011. These recommendations were unanimously endorsed by CEOS agency principals.

Result: In the near-term, plans are being made for CEOS agencies to have 1 or 2 people to be part of the relevant air quality geostationary satellite mission science teams. In addition, ACC will organize an air quality OSSE activities workshop (including the intercomparison of existing retrieval algorithms) and will coordinate a societal benefit area value assessment of air quality observations, leveraging recent GCOS and GEO User Interface Committee efforts.

3. Total Ozone Data Set Intercomparison

a. Instrument and algorithm team representatives and modelers from the U.S. and Europe spent 1 ½ days discussing technical aspects of their instrument's capabilities, algorithm development, and calibration/validation activities relating to the measurement of total ozone. The teams also described their efforts to merge the multiple data sets derived from their respective missions (SBUV/TOMS and

GOME/SCIAMACHY). There was some discussion of the utility of these total ozone data sets to climate modelers.

b. It was noted that the Brion-Daumont-Malicet (BDM) ozone cross sections are now used in the US (NASA, NOAA) and Europe (ESA), which facilitates the intercomparison of these different ozone data sets.

c. Discussion among the groups concluded that the total ozone record is rather unique among the set of GCOS-defined essential climate variables. There are three independent, long-term data sets of comparable quality - Brewer-Dobson ground-based network, SBUV/TOMS, and GOME/OMI/SCIAMACHY – with errors of the same order (none of them can be identified as the reference data set). There was not a consensus to merge these sets into a harmonized product (e.g. modelers present at the meeting stated that they would rather prefer to use 3 different (short) data sets with very clear error characteristics rather than a merged long term data set). Rather, ACC could serve as a venue to coordinate international collaboration in further characterizing the errors and uncertainties in these data sets and, working with modelers, address some of the science issues, such as ozone's season cycle, the QBO, the ozone response to volcanic eruptions, and the detection/attribution of ozone recovery.

   Recommendation: ACC will hold a follow-up workshop total ozone error characterization in conjunction with the next SPARC ozone profile initiative meeting, tentatively scheduled for April/May 2012 in the Washington, DC area.

## 3.0 Summary of Workshop Topics and Discussions

### 3.1 Introduction

Claus Zehner (ACC Co-Lead, ESA) discussed the scope of the meeting. The ACC's key objectives are to collect and deliver data to improve predictive capabilities for coupled changes in the ozone layer, air quality, and climate forecasting and to meet participating agency priorities that are aligned to the GEO societal benefit areas (e.g., health, climate, energy, ecosystems). ACC works to facilitate international collaboration among space agencies and establish a framework for long term coordination of CEOS's goals. The previous CEOS ACC meeting (ACC-6, minutes and presentations available at: http://www.ceos.org/index.php?option=com_content&view=category&layout=blog&id=53&Itemid=94 ) concentrated on a discussion of agency activities in generating essential climate variables. The goals of the present meeting are to:

- Review ongoing ACC activities including existing projects and the Air Quality constellation position paper.
- Follow-up on essential climate variable (ECV) generation – focus on total ozone as there are multiple, independent records of long length
- Review space agencies activities on total ozone long-term data sets
- Discuss the role of ACC cooperation in improving these long-term records and identify concrete actions.

Comment from Paul Newman (NASA): There is a definite need for international cooperation. Total ozone serves as a fundamental variable for assessment activities; e.g., Montreal Protocol. But, there's also a focus on related science issues. One of the crucial discrepancies are the trends in the integrated column in the tropics, derived from ozone profile measurements, compared with those derived from total ozone data sets. Total ozone is a crucial observation to assess ozone recovery.

## 3.2 Agency Tour de Table

3.2.1 EUMETSAT. Rose Munro reported on the forthcoming launch of MetOp-B next April (currently set for 9 April 2012) to fly in tandem with MetOp-A. There are questions on how to operate two GOME instruments in this configuration. Since there will be a half orbit delay, level 1 data may be taken in either 50-minute overlapping swaths or in incremental swaths. Since MetOp-A continues to age, eventually the agency will revert back to one satellite.

3.2.2 DLR. Diego Loyola discussed the Methane Remote Sensing Lidar Mission (MERLIN) mission. This is a joint mission with France to measure atmospheric methane from space using an integrated path differential absorption lidar. It will help calculate methane sources on the ground with the help of inverse modeling. Launch is planned for 2014 and the instrument is to be built in Germany. The orbit will be sun synchronous, but the time of day has not yet been defined. Column methane will be the principal measurement, but they may in addition try for profile methane. The mission is fully agreed and budgeted.

3.2.3 NASA. Richard Eckman discussed the Earth Science Division upcoming launch schedule, including Aquarius (with CONAE, sea surface salinity), NPP (with NOAA, quasi-operational meteorological observations), LDCM (with USGS), ICESat-II (ice dynamics), SMAP (with CSA, soil Moisture, freeze/thaw), GPM (with JAXA, precipitation), OCO-2 (global $CO_2$). In addition, the Southeast Asia Composition, Cloud, Climate Coupling Regional Study (SEAC4RS) is an airborne field campaign focusing on atmospheric composition and chemistry planned for later in 2012. The agency FY12 budget is a topic of much uncertainty.

3.2.4 NOAA. Larry Flynn discussed NOAA support for various air quality applications with NASA and EPA. Simultaneous Nadir Overpass (SNO) with OMI and GOME-2 can be used to show agreement when sampling the same atmosphere at the same time because there will be some time where 2 satellites cross at the same place or cross at the same latitude. GFS-GOCART simulations of biomass burning emissions from multiple geostationary satellites are in progress with considerable interaction between NASA, NOAA, and the Department of Defense. OMPS will be launched later this year. Cooperation in total column carbon is ongoing.

3.2.5 CSA. Thomas Piekutowski presented current and planned missions of atmospheric relevance. Current missions support science operations of MOPITT on Terra (1999 to present) and OSIRIS on Odin (2001 to present). CSA is working to enable the use of OSIRIS vertical profile measurements of $O_3$, aerosols, $NO_2$, and BrO for the generation of ECVs and to contribute to assessment reports. Future missions be considered include:

- Solar occultation: mission studies to provide technology development for improved vertical resolution and range of Occultation FTS.
- Limb Scatter: mission assessment studies are ongoing and technology development for improved vertical resolution and horizontal sampling (follow-on to OSIRIS) and for new instruments: SHOW, TICFIRE.There is a concept for two satellites with highly elliptical orbits to support polar communications and weather (PCW). These spacecraft will loiter over the high latitudes for long periods for near-geostationary observations.

- Ground-based observations at the Polar Environment Atmospheric Research Laboratory (PEARL) at 80°N used for validation and modeling of GOSAT.

3.2.6 ESA. Claus Zehner made a presentation on agency missions including its heritage missions (ERS-1 and ERS-2) with the latter coming to an end of its life. Envisat is still operational and given its large size, there are issues for its decommissioning. A number of scientific missions were mentioned including SMOS, Swarm, GOCE, CryoSat-2, ADM-Aeolus, and EarthCARE. The Scientific missions are to understand our changing Earth, study the atmosphere, hydrosphere, cryosphere, biosphere, and geosphere. GOCE is mapping the Earth's gravity field with better accuracy (with reference to ocean circulations, sea level change, and the Earth's interior). SMOS is measuring soil moisture and ocean salinity. CRYOSAT is mapping changes in ice thickness over land and oceans. Future missions include SWARM which will map the Earth's magnetic field (2012), ADM-AEOLUS to measure wind profiles on a global scale (2013), and EARTHCARE to acquire vertical profiles of clouds and aerosols (2014). Missions in the development phase include Explorer 7 (Biomass or CoReH2O or Premier) with a selection planned in 2012 and Explorer 8 (Carbonsat or FLEX with four spectral bands to look at vegetation). Phase A is to start this autumn.

Operational missions supporting the space segment of GMES include:

- Sentinel 1 – SAR imaging all weather, day/night applications, interferometry (2012/2015)
- Sentinel 2 – Multi-spectral imaging for land applications, urban, forest, agriculture, etc. continuity of Landsat, SPOT (2013/2016)
- Sentinel 3 – Ocean and global land monitoring with wide-swath ocean color, vegetation, sea/land surface temp, altimetry (2013/2017)
- Sentinel 4 – Geostationary atmospheric – atmospheric composition monitoring, trans-boundary pollution detection (2018+)
- Sentinel 5 – Low-orbit for atmospheric composition monitoring (2019+)
    - Sentinel 4 and 5 are components of other satellites
    - Sentinel 5 Precursor: launch planned for spring 2015. This will be a stand-alone gap-filler with hope to fly in loose formation with NPP.

Note that Sentinel 4 and 5 are ESA payloads to be launched respectively on the geostationary EUMETSAT Third Generation (MTG) platform and on the sun-synchronous EUMETSAT post-EPS platform.

## 3.3 Status of Ongoing ACC Activities

3.3.1 Briefing on CEOS Strategic Implementation Team (SIT-26) Meeting (Claus Zehner, ESA)

At the May SIT-26 meeting in Frascati, Claus gave a presentation on ACC status and the key issue was the Air Quality constellation position paper (see Al-Saadi presentation, below, for details). The paper was endorsed by the SIT members. The interaction between CEOS and the WMO Global Climate Observing System (GCOS) was discussed. The issue of ACC contribution to the CEOS work plan was discussed. ACC-7 participants were concerned about CEOS reporting requirements and the number of overlapping organizations and acronyms (e.g., relationships between CEOS, GEO, GEOSS, and WMO GCOS).

*Results*: CEOS is an implementing organization and the Constellations are meant to demonstrate international collaboration in specific areas. ACC should find clear niches to do concrete things and make them visible to the space agency community (e.g. harmonized ECV generation). .

3.3.2 Final Position Paper on Future Air Quality (AQ) Constellation/Next Steps (Jay Al-Saadi, NASA)

The AQ Constellation position paper was finalized following multiple reviews within ACC and with the external community. Background: several countries are planning on launching multiple geostationary satellites for air quality monitoring over the next decade so combining their data is useful for global relevance. The role of the ACC would be to extend the scope of the science and applications from the regional to global scales. The paper's recommendations were presented at the SIT-26 meeting and were endorsed with no objections.

The next step is acting on the recommendations. In the near term (1-3 years), CEOS agencies will coordinate 1 or 2 people to be part of the mission science teams, ACC will organize an air quality OSSE activities workshop, and coordinate an SBA value assessment of air quality observations leveraging recent GCOS and GEO User Interface Committee (UIC) efforts (focused more towards air quality and delivering data to users). Each mission is meant to deliver societal benefits, but nuts and bolts need to be worked out.

The question was raised on how this effort differs from the existing WMO SCOPE activity? Air Quality is not really a key SCOPE activity (especially on near real time delivery to enable forecasting for AQ applications)

In the longer term (2018+), the paper recommends an agreement on an open data policy for AQ relevant data and the support the establishment of common cal/val standards working with WGCV (which is already happening among some agencies, e.g., ESA, but other global agencies have to agree), organize a workshop of AQ model intercomparison, undertake best efforts to overlap geostationary AQ missions by at least one year, support evaluation of strategies for extending coverage, including best use of complementary satellite measurements and possible approaches for common instruments.

An opportunity exists to define a vision/roadmap/strategic document for "AQ from Space" by which future solicitations can evaluate proposals that come in. Advocacy for new mission concepts and extended coverage (e.g., into the southern hemisphere) could be considered. It was also suggested that the Canadian PCW could be incorporated into the constellation planning.

Near-term challenges are:

- To define a clear CEOS action for each recommendation
- To nominate Agencies representatives for each activity and to secure resources.
- To define constellation products more quantitatively (based on lessons learned from single instruments like OMI and GOME)
- To re-engage with Japanese colleagues to bring them back into the process.
- To include airborne campaigns in geostationary AQ mission development, including algorithms and cal/val (e.g. NASA DISCOVER-AQ)
- To address beside OSSEs also algorithm intercomparison

3.3.3 Volcanic Ash Monitoring (Claus Zehner, ESA)

Volcanic aerosols are an aviation hazard because of the potential to clog engines and cause catastrophic aircraft failures. Nine Volcanic Ash Advisory Centers (VAACs) have been established worldwide by ICAO. The recent Grimsvotn eruption on 25 May highlighted the issue. Aerosols were injected to 20 km. Scientific forecast models like FLEXPART are now constrained by satellite observations showing better results than without it. But challenges remain, since the distinction between ash and SO2 is not always made. Combining multiple satellite information sources can improve forecasts significantly. The ongoing ACC project plans to improve eruption source information by using satellite measurements, improve satellite retrievals on ash concentration and height, to develop new modeling capabilities, and to make the alert system based on satellite data global. The basic goals of the project have been achieved. It is now ongoing task.

3.3.4 ACC Contributions to the CEOS Response to the GCOS Implementation Plan/Next Steps (Richard Eckman, NASA, for Mitch Goldberg, NOAA)

CEOS is currently preparing a coordinated response to the new, 2010 edition of the GCOS Implementation Plan. The critical issue for GCOS is to ensure continuity and improvement of satellite and in situ networks and enable the generation of high quality global datasets for the ECVs. The actions in the GCOS IP relevant to ACC include long-term limb scanning satellite measurements, assessment of space-based measurements of $CO_2$ and $CH_4$, continuity of ozone data records (column, tropospheric, and profile), and the continuity of space-based measurements of precursors including $NO_2$, $SO_2$, HCHO, and CO. The CEOS response will reinforce the needs expressed in the GCOS Satellite Supplement by better quantifying what can be achieved with current and additional funding.

Prior to SIT-26, initial templates for these activities were completed. The limb scanning activity was considered by a group of four ACC members, while Claus took care of the initial input for

the other action templates. Claus will contact ACC members in due time to finalize these action templates and they will also be circulated to the extended academic community of atmospheric composition researchers.

On GCOS actions relating to water vapor and aerosols, which are currently assigned to ACC, the meeting participants felt that these issues extended beyond the current scope of the ACC, are covered by other activities (e.g. GEWEX) and should be excluded from consideration. Issues relating to radiation budget were also deemed to be outside the ACC's remit.

3.3.5 The Atmospheric Composition Portal (ACP) (Stefan Falke, Northrop Grumman)

Interest was expressed in exploring further ways that ACP can meaningfully be used in ACC activities. The objectives of the Portal are to provide access to data and tools for remotely sensed data, help foster interoperability of data, identify common features of users to provide value and complementary capability, and to work with partners. ACP's aim is to develop a framework by using best practices in IT and applying them to atmospheric science. The current ACP-Beta is hosted at http://wdc.dlr.de/acp/. The beta release features improved data access (MODIS, OMI, GOME-3, SCIAMACHY/AATSR), contextual info to help understand data, tools for processing and analysis, collaboration tools for exchanging analysis and other information.

ACC feedback is solicited on which features are most useful for ACC. In addition, an ACP Science Advisory Group has been proposed, in which members of ACC would play a core role. Stefan believes that the success of ACP requires ongoing direction and advice from scientists. He envisions two ACC members working closely with ACP development team.

Ongoing Collaborations include QA4EO, AC modelers, AC emissions, and the GEOSS Air Quality Community of Practice Information Network. The goal is to get more people involved. A GEOSS AQ Community of Practice workshop is being organized for 23-25 August in Croatia.

## 3.4 Total Ozone Records/Algorithms

3.4.1 A 41 Year Record of Total Column Ozone Derived from the SBUV Series of Instruments (Richard McPeters, NASA)

A series of eight backscatter UV (BUV) instruments has been measuring ozone from space since 1970. There have been two approaches to creating time series from these multiple data sets: (1) make simple adjustments to account for calibration offsets by using ground-based Dobson-Brewer data to create a merged/adjusted ozone time series or (2) Merged Ozone Data (MOD) which uses overlap periods of SBUV, TOMS, and OMI measurements and proxy data to produce a purely satellite-based time series without reference to the ground-based data record.

*Conclusions*: A coherent, trend-quality 41-year ozone time series has been produced, with global ozone decrease since 1979/1980 of 4%, with no significant trends in the equatorial zone. At 45°N, a -4.4% trend in total column is revealed. The accuracy of the SBUV time series appears to be better than that of the ground network normally used for validation Column ozone above 101hPa (global average) is consistent with Aura MLS and with SAGE II at the 1- 2% level (but with an offset). The plan is to release the v8.6 total ozone time series this summer, with NOAA 16, 17, 18 and then Nimbus 7 and 4. NOAA 9 and 11 will require more analysis and Nimbus 7 TOMS, Earth Probe TOMS, and OMI $O_3$ will be released this fall.

3.4.2 Quality of SBUV and TOMS Total Ozone Datasets (P.K. Bhartia, NASA)

Nine SBUV-like instruments have launched since April 1970. The instruments are fairly consistent but there are some differences. This is viewed as one of the most successful NASA/NOAA collaborations. Key features of the SBUV and TOMS instruments were reviewed. The total $O_3$ algorithms were also discussed with focus on the new SBUV v8.6 algorithm, which is based on Rodgers' optimal estimation method and is optimized for long term changes.

*Summary and Recommendations*: Calibration accuracy is 1-2 Dobson Units (DU) for Nimbus 7 and NOAA 16/17/18, 2-3 DU for others. Algorithm accuracy is about 3 DU (short term) and 0.5 DU (long term) at low SZA. The surface-25 km column has similar accuracy as total $O_3$, and the stratospheric column has similar accuracy at SZA>75°. The effect of volcanic aerosols is still TBD, but is likely small.

Nimbus 7 and Nimbus 16 shouldn't be adjusted to ground-based data. Validation/correction of SBUV total $O_3$ record, existing TOMS, and OMI/TOMS data need to be adjusted to SBUV until a new version is released. Brewer zenith sky data should be reprocessed using a satellite-like algorithm (Fioletov et al., Journal of Geophysical Research, 2011).

3.4.3 Report on NOAA Satellite Measurements of Total Ozone (Larry Flynn, NOAA)

NOAA-16 through NOAA-19 are still making good measurements. Preparations are under way for near real-time and cal/val activities for OMPS on NPP, which is due to launch later this year.

NOAA is collaborating closely with NASA/GSFC on the v8 SBUV algorithm (described earlier by Rich McPeters and P.K. Bhartia). NOAA is working with the Chinese Meteorological Administration (CMA) on a v8 algorithm for FY-3A and 3B TOU and SBUS and collaborating with EUMETSAT on GOME-2, and with NASA, KNMI and FMI on OMI. Other activities include the collaboration with the NPP Science Team on the OMPS Limb profiler, providing data and consultation on SBUV/2 results for 2000-2010 comparisons to European satellite measurement of ozone profiles. A significant change in the v8 ozone algorithm is the switch to the more recent Brion-Daumont-Malicet (BDM) ozone cross sections and the inclusion of Ring corrections.

3.4.4 The Main Improvements in the GOME Data Processor v5 Algorithm and Future Planned Updates for the Ozone_cci Project (Michel van Roozendael, BIRA-IASB)

Spectral fitting approaches are more common in Europe and may be much less sensitive to calibration issues. The GDP4 algorithm is in current use for GOME1 data processing. This DOAS based algorithm has been transferred to SCIAMACHY. The new GODFIT/GDP5 algorithm uses a direct fitting scheme of measured reflectivity using on-the-fly MS radiative transport calculations (LIDORT v3.3); including a temperature shift adjustment algorithm that makes it insensitive a priori temperature information. Furthermore the recent BDM $O_3$ cross-sections, a parameterized Ring correction, and albedo closure are being used. GDP5 is the current ESA GOME baseline algorithm, to be implemented this summer. Through the ESA_cci project GDP5 will be further improved (e.g. cloud information retrieval, Ring correction) and implemented to SCIAMACHY and GOME2.

## 3.5 Calibration/Validation/Data Merging

3.5.1 Key Aspects of GOME-2 Calibration (Rose Munro, EUMETSAT)

Ongoing GOME-2 calibration activities were described With respect to changes from the last calibration from ~5 years ago, the key issue is how does one determine whether it's an instrument or a measurement problem? One needs to consider changes in slit function, irradiance response, PMD spectral calibration (one PMD), polarization sensitivity, calibration campaign extended for further measurements and investigations.

*Results:* For the slit function, the FWHM has changed by up to 20% in some channels. Investigations suggest an on-ground to in-flight change in GOME-2 FM3 on MetOp-A plus long-term changes. A possible source is small changes in thermal or mechanical stress on the gratings. Could this be relevant to other instruments?

A slow onset of degradation was observed after the 2$^{nd}$ throughput test in channel 1 and 2 (a 50% loss of signal in UV during a 3-year period was noted). The instrument is stable now in channels 3 and 4. There is belief that additional degradation is close to the detectors or even on the detectors. There could be issues with outgassing of the printed circuit boards.

3.5.2 Lessons Learned from the Validation of GOME Total Ozone Columns (Jean-Christopher Lambert, BIRA-IASB, presented by Michel van Roozendael)

The overarching goal is to determine the fitness of satellite $O_3$ column data for intended use(s) and this is usually done by comparison with reference data; e.g., Brewer, Dobson, NDACC, UV-VIS, and other satellites. A number of conclusions were noted, relating to user requirements, data set length (e.g., at least one year of data is required for proper error characterization), validation of bias and stability, and validations efforts.

*Conclusions*: Validation must encompass studies of several dependences and look at statistics with care. In many cases, validation needs to abandon the idea that one is comparing true vertical columns. Generic validation protocols exist for atmospheric data and services (PROMOTE, MACC, Ozone_cci, PVP, etc.).

During the discussion following the presentation, it was suggested the CEOS WGCV may wish to develop an illustrative validation protocol for satellite ozone column and profile data.

3.5.3 Impact of Ozone Absorption Cross Sections on Ozone Data Records (Johanna Taminnen, FMI)

Activities relating to the Absorption Cross Sections of Ozone committee (ACSO), 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), were described. Its charter is to review different measurements, determine their impact on algorithms, and make recommendations.

*Conclusions:* With respect to the laboratory measurements, investigations confirm the high quality of the BDM $O_3$ cross-sections. The ASCO switch from the older Bass & Paur (1985) [BP] measurement to BDM $O_3$ cross-sections is very well justified from the laboratory perspective. The effects of changing absorption cross sections from BP to BDM is expected to be small, with the main difference between co-located Brewer and Dobson (AD) measurement expected to become larger when using BDM instead of BP. Brewer ozone profiles are expected to be of higher quality when using BDM.

There is general agreement that BDM is more accurate than BP. The residuals and effective temperature are typically slightly better when using BDM, total ozone and low resolution ozone profile groups general in favor of changing to BDM, with differences expected when changing from to BDM typically in the 1-3% range for total ozone, with larger differences (tens of %) with low resolution ozone profiles from nadir instruments. For high resolution ozone profiles, BDM is not fully suitable because of the need for wider temperature and wavelength coverage.

The BDM cross sections are now used in the US (NASA, NOAA) and Europe (ESA), which facilitates the intercomparison of these different ozone data sets.

3.5.4 Total Ozone and GEOSS, Paths Forward for Total Ozone ECVs (Larry Flynn, NOAA)

Consistency in the production of total ozone essential climate variables was emphasized. It was noted, for example, that the Chinese don't want to change their ozone cross sections used in their retrievals. This could lead to future problems for the intercomparison of data sets.

Long-term stability is also a major issue. Outputs needed for assessing stability include climatology and efficiency (e.g., averaging kernels and sensitivities). Validation with ground-based Dobson and Brewer measurements is necessary.

3.5.5 The Merged Weighting Function DOAS (WFDOAS) Total Ozone Dataset Derived From GOME-1, SCIAMACHY and GOME-2 (1995-present) (Sebastian Dikty, University of Bremen)

The IUP University of Bremen "GSG" merged data set was described. Ozone datasets have been created by IUP-UB for science and WMO UNEP Assessments, and include WFDOAS total ozone, SCIAMACHY limb ozone profiles, vertical profiles from nadir, SCIAMACHY occultation profiles, total ozone columns from BREDOM DOAS ground network, data assimilation, and the measurement of new ozone absorption cross-sections.

*Results:* A comparison of GOME minus Brewer time series reveals the following trends: GOME-1 stable, SCIAMACHY -4%/decade until 2006, -1% until 2010, seen with all algorithms. For GOME-2 no trend was noted, but with a jump of -1% after September 2009.

Important issues when merging data sets include the justification of the reference data set, overlap periods, bias/ratio and trend (linear) correction, changes in instrumental trends, and sudden jumps in data record. The global anomalies and extreme conditions observed within the last decade could be climate related. The GSG merged total ozone data is available at www.iup.uni-bremen.de/gome/wfdoas.

## 3.6 Merged Total Ozone Sets/Algorithms To Generate Them

3.6.1 Long-term total ozone in climate models (Richard Stolarski, Johns Hopkins University)

Some issues with merging multiple data sets were discussed, which include drifting instrument calibration over time and the calibration offsets from one instrument to another. Offsets can be determined from measurement overlap. The consideration of systematic uncertainties: e.g., TOMS and SBUV on Nimbus 7 is also an issue. Data gaps can cause additional problems in estimating uncertainties. Drift offset uncertainty is important for determining how good the records are.

It was emphasized that making data readily available is important. A modification history (i.e., using metadata) to flag issues showing where big changes were made is essential to maintain traceability.

With respect to the use of total ozone data to confront models, as a first step, these data serve as validation in a semi-quantitative self-evaluation for entrance into the ozone response and prediction "game". But, more can be done using the total ozone record. As mentioned by others during the meeting, problems revealed by a failure to simulate total ozone lead to the need to evaluate other factors, like the ozone profile. A more quantitative analysis of the comparison of total column data and model simulations is needed.

Care must be taken in dealing with multi-model means since they all have their own (different) wind fields. A mean of the models dampens down the variability, which is not realistic! The CCMVal process oriented comparisons are useful, e.g., age of air diagnostics.

*Conclusion:* With respect to the detection/attribution of ozone recovery, the long-term change in ozone is the important issue. There is a response to changes in ozone depleting substances (ODSs) and a response to GHG changes (e.g., the residual circulation is speeding up). So is the ozone change due to chlorine changes or circulation changes? The latitudinal signature of these changes is different, so attribution may be possible over longer time scales.

3.6.2 GOME-type Total Ozone Data Record and Evaluation of Climate-Chemistry Models (Diego Loyola, DLR)

It was noted that the GOME algorithms have evolved over time. GDP 2.0 was used in 1996 and now GDP 4.4 is in use for GOME-2 retrievals in 2010. There are issues related to merging GOME, SCIAMACHY, and GOME-2. Offsets are seen if the data are just plotted together. How does one match the data sets?

One can use climate models to evaluate the data (in a manner not duplicating the CCMVal effort). Variability was assessed using the standard deviation from the model vs. data. Decadal evolution was also analyzed. Zonal trends have been examined between multiple models and merged data sets. With respect to the GOME-2 vs. OMI/TOMS intercomparisons, drift has been

detected in the period from 2009 onwards. The ESA CCI phase 1 project addresses, inter alia, improved merging algorithms.

3.6.3 Using data assimilation techniques to generate a long term total ozone record (Ronald van der A, KNMI, presented by Michel van Roozendael)

The objective of the study is the development of a long-term, consistent, and complete ozone record for the past 30 years. All publicly available satellite data are to be used. The steps involved in this analysis are: (1) correct data to avoid biases and (2) assimilate data in a CTM to achieve complete global and temporal coverage.

The KNMI model is used for the assimilation. Forecast error modeling is an important component of this technique. Ozone and UV data are available on the MACC site and on TEMIS (http://www.temis.nl/macc/index.php?link=o3_msr_intro.html).

3.6.4 Merging Total Ozone Data Sets – Some Warnings (Vitali Fioletov, Environment Canada)

Various techniques to merge total ozone records were discussed. It was noted that the NIWA (Bodeker) assimilated total ozone data set is based on multiple satellite data sets normalized to ground based data. A difference plot of GOME versus EP TOMS from 1996-2000 shows problems in tropics with ~3% errors.

During the discussion, it was noted that biases may not make trend calculation wrong. There are significant issues with EP TOMS, so this may not be the best good data set to use for these comparisons. Concern was expressed about how the algorithm treats surface albedo effects. But, it was noted that these issues don't necessarily change with time much. So, a bias may not impact time-dependence. However, it was suggested that albedo could change significantly at high latitudes. It was unclear how much of an effect this might be.

## 3.7 Other Topical Presentations

3.7.1 Ozone Research Managers 8th meeting: Perspective and Recommendations (Mike Kurylo, University of Maryland Baltimore County)

The Ozone Research Managers (ORM) Meeting was held last May, and is mandated by the Vienna Convention for the protection of the ozone layer. It is required to occur every three years, 6 months prior to the meeting of the parties in order to review international ozone and UV-B research programs and to make recommendations for further international collaboration.

There is a close relationship to the WMO-UNEP assessments (scientific, environmental effects, technology, and economic). All of these assessments are required under Vienna protocol. However, neither policy recommendations nor research planning documents are produced at the ORM; rather they provide input for both activities.

Issues addressed at the meeting included:

- Continuation and expansion of systematic measurement and analysis capabilities for tracking the evolution of ozone and climate related source gases
- Detection of ozone recovery from ODS impact
- Attribution of changes in radiation forcing or climate
- Global record of ground-based UV measurements
- Studies of the differences in total ozone profiles in the tropical regions between measurements and models was seen as a continuing research need
- Co-location of profile and column measuring instruments is needed for "truthing" purposes.
- Temperature profile data records and measurement capabilities leading to recommendations for new temperature measurement systems.

3.7.2 Lifetimes of long-lived stratospheric species – New SPARC initiative (Paul Newman, NASA)

The executive summary from the most recent ozone assessment expressed concerns about the lifetimes of species, e.g., F-11. There is increasing concern that these lifetimes may be wrong. Also, the lifetime of $CCl_4$ seems problematic; its overall budget remains poorly understood. The NASA GMI model has longer lifetimes for most long-lived species compared to the WMO 2007 recommendations. In light of these concerns, a SPARC lifetime re-evaluation project was endorsed by the steering group in February. Activities will include:

- Re-evaluate numerical values for lifetimes
- Improve uncertainty estimates
- Study the influence of different lifetime definitions (e.g., steady-state vs. instantaneous)
- Address the influence from a changing climate (e.g., changes in Brewer Dobson circulation)
- N2O and CH4 are also of interest, particularly with respect to GHG issues.

- Timetable: Draft reports through 2012, final release: April 2013

During the discussion, there was concern expressed about the lack of consideration of $SF_6$ and some other HFCs (e.g., 125) that are believed to be significant. Also, the importance of calculating tropospheric OH correctly in the models was discussed.

3.7.3 SPARC Initiative of Ozone Profiles (Jan. 2011 workshop) (Claus Zehner, ESA)

The SPARC/IO3C/WMO-IGACO-03/UV Workshop on Past Changes in the Vertical Distribution of Ozone held in January was described. This follows on from the SPARC 1998 report on the "Assessment of Trends in the Vertical Distribution of Ozone".

SAGE had been a significant contributor to the vertical profiles analysis. But, both it and HALOE have been off since 2005. Other satellite-based profile measurements are now available: e.g., ODIN, Envisat, Scisat, and Aura. The goal of this new activity is the generation of reliable knowledge of the long-term stratospheric ozone profile evolution. The effort also involves ground-based measurements.

The Action Plan includes a number of initiatives: e.g., long-term satellite data quality, last decade of satellite observations (with a focus on climate variability), ozonesondes, umkehr, and other ground-based measurements (including lidar, FTR, microwave), and approaches to merging multiple data sets. The initiative is working towards contributing to the next UNEP/WMO assessment report (with a 2014 delivery).

ESA will support the SPARC initiative with a call for proposals to be released in early June. This is complementary to the ESA CCI initiative and will include issues such as improving selected European data sets, creating stratospheric temperature climatologies, and defining new methods of merging ESA and external data sets. There is also consideration of future stratospheric climate record generation (e.g., aerosols, water vapor).

### 3.8 Discussion Topic: *Is there a need for an ACC activity (as an international co-operation project) on linking US and European Total Ozone Records?*

The final afternoon discussion dealt with the question tabled at the start of the meeting which dealt with the need for an international collaborative effort to link US and European total ozone records into a single, harmonized data set.

The NASA Goddard group noted that there are now three independent data sets: the Brewer-Dobson ground-based network, SBUV/TOMS, and GOME/OMI/SCIAMACHY. These three records are comparable in quality and the errors are of same order. Their recommendation was to continue to make adjustments at the calibration level and at level 1, while maintaining the independence of the three algorithms. The length and quality of total ozone records is rather unique among atmospheric composition-relevant ECVs. For many variables sufficient long-term satellite records don't exist. As they mature they may reach the same point as total ozone.

From the ozone assessment perspective, it was argued that the independence of the data giving similar results gives good support for making conclusions. Merging moves a step away, adds another layer of uncertainty removed from the individual data sets and the knowledge base that created them. This could potentially lead to new issues and problems.

Several felt that it is critical to engage each group on error characterization and the best use of data in trend detection. Further progress is needed in attributing /quantifying differences between the various total ozone records; for example, what parts of the algorithms are causing them.

Some suggested that the value of merged datasets is in climatologies. For example, climate modelers want ozone climatologies for use in their models. The question was raised whether ACC should coordinate the production of such climatologies, but no consensus was reached. This may be more relevant to the related ozone profile initiative.

*Conclusions*:

1. There was general agreement to keep the data sets independent, but intercomparisons to better understanding the differences in algorithms would be very useful. And, further, the ACC provides an excellent forum to conduct and coordinate these activities.
2. Error characterization for total ozone is a challenging problem and more work needs to be done. The group consensus is to address total ozone error characterization at a follow-on ACC workshop, to be held in conjunction with the SPARC ozone profile initiative meeting, tentatively scheduled for April/May 2012 in the Washington area.

# Atmospheric Composition Constellation Meeting (ACC-7) - 21-22 June 2011, Columbia, Maryland, USA

## Agenda

| | | |
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| **June 21** | **Tour de Table** | |
| 08.30 – 09.00 | Registration | |
| 09.00 – 09.10 | Welcome/Logistics | R. Eckman/NASA |
| 09.10 – 09.20 | Scope of this Meeting | C. Zehner/ESA |
| 09.20 – 10.30 | Tour de Table on Space Agency Activities (oral only or a 3 slides presentation on last year activities and plans for the near future – on the topic atmosphere) | CNES, CSA, DLR, ESA, EUMETSAT, JAXA, NOAA, NASA etc. |
| 10.30 – 11.00 | **Coffee Break** | |
| | **Status of ongoing ACC Activities** | |
| 11.00 – 11.10 | Short Briefing of the last CEOS SIT Meeting (May at ESA/ESRIN) | C. Zehner/ESA |
| 11.10 – 11.30 | Final Position Paper on a Future Air Quality Constellation/next Steps | J. Al-Saadi/NASA |
| 11.30 – 11.50 | Volcanic Ash Monitoring from Space – the Grimsvotn 2011 Eruption | C. Zehner/ESA |
| 11.50 – 12.10 | Status of ACC Contributions to the CEOS Response to the GCOS Implementation Plan/next Steps | R. Eckman/NASA |
| 12.10 – 12.20 | The Atmospheric Composition Web-portal – Collaboration with ACC | S. Falke/Northrop Grumman |

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| 12.20 – 13.30 | **Lunch Break** | |
| | **Total Ozone Records/Algorithms** | |
| 13.30 - 14.00 | 41 year record of Total Column O3 derived from SBUV series of instruments | R. McPeters/NASA |
| 14.00 - 14.20 | Quality of SBUV & TOMS total O3 Datasets | P. K. Bhartia/NASA |
| 14.20 – 14.40 | Report on NOAA satellite measurements of Total Ozone and Ozone Profiles | L. Flynn/NOAA |
| 14.40 – 15.00 | The main improvements in the GOME Data Processor Version 5 Algorithm and future planned updates for the Ozone_cci Project | M. van Roozendael/BIRA-IASB |
| 15.00 - 15.30 | **Coffee Break** | |
| | **Calibration/Validation/Data Merging** | |
| 15.30 - 15.50 | Key aspects of the calibration of GOME 2 spectra | R. Munro/EUMETSAT |
| 15.50 – 16.10 | Lessons learned by doing the geophysical validation of GOME Total Ozone Columns | J.C. Lambert/BIRA-IASB |
| 16.10 – 16.30 | Impact of ozone absorption cross sections on ozone data records | J. Taminnen/FMI |
| 16.30 – 16.50 | Total Ozone and GEOSS; Paths forward for Total Ozone ECVs | L. Flynn/NOAA |
| 16.50 – 17.10 | The merged Weighting Function DOAS (WFDOAS) total ozone data set derived from GOME1, SCIAMACHY, and GOME-2 (1995-present) | S. Dikty/University Bremen |
| **18:30** | **Dinner Near Hotel** | |

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| **June 22** | **Merged Total Ozone Sets/Algorithms to generate them** | |
| 09.00 – 09.20 | Long-term total ozone in climate models /Thoughts on merging long-term data sets | R. Stolarski/Johns Hopkins University |
| 09.20 – 09.40 | GOME-type Total Ozone Data Record and evaluation of Climate-Chemistry Models | D. Loyola and M. Dameris/DLR |
| 09.40 – 10.00 | Using data assimilation techniques to generate a long term total ozone record | R. van der A/KNMI |
| 10.00 – 10.20 | Merging total ozone data sets | V. Fioletov/Environment Canada |
| 10.20 – 11.00 | **Coffee Break** | |
| 11.00 – 11.20 | Lifetimes of long-lived stratospheric species initiative: A new SPARC initiative | P. Newman/NASA |
| 11.20 – 11.40 | Brief Report on the IO3C/WMO initiative on ozone profiles and the ESA SPARC Initiative | C. Zehner/ESA |
| 11.40 – 13.00 | **Lunch Break** | |
| 13.00 – 15.00 | Discussion on: Can we do a 'best effort' ACC project on the generation of a total ozone long term record? What are the time constraints (e.g. next WMO ozone assessment)? On which projects can we build upon? Who are the key persons? Concrete Action Items to get it done? | All |

**7th Atmospheric Composition Constellation Workshop (ACC-7) – 21-22 June 2011**
**Columbia, Maryland, USA**

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