Minutes of the
9th Atmospheric Composition Constellation Workshop (ACC-9)
Darmstadt, Germany
18-19 April 2013

1.0 Executive Summary

The Committee on Earth Observation Satellites (CEOS) ACC-9 was held at EUMETSAT in Darmstadt, Germany, on 18-19 April 2013. 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 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.

Researchers from participating CEOS agencies, related universities, and supporting organizations participated in person or by WebEx. These agencies included the Aristotle University of Thessaloniki, Belgian Institute for Space Aeronomy, China Meteorological Administration/National Satellite Meteorological Center, CNRS, DLR, Environment Canada, ESA, Euro-Mediterranean Center on Climate Change (CMCC), EUMETSAT, Finnish Meteorological Institute, Forschungszentrum Jülich, Harvard University, Karlsruher Institut für Technologie (KIT), KNMI, LATMOS, NASA, National Center for Atmospheric Research. NOAA, SSAI, University of Bremen, and Yonsei University. We are grateful to Rose Munro and the EUMETSAT staff for meeting logistics and providing WebEx remote access participation.

The Workshop addressed four principal topics: 1) Long-Term Total Ozone Data Set Harmonization, (2) Volcanic Ash Monitoring From Space, (3) ACC Air Quality Constellation, and (4) Greenhouse Gas (GHG) ECV generation. The workshop Agenda and participant list are attached to these minutes. The presentations can be found at http://www.ceos.org/acc.

2.0 Workshop Highlights and Recommendations

1. Total Ozone Measurement Coordination

    a. The setting up of a common validation protocol for the ACC-9 total ozone workshop (all using the same reference data for validation, availability of all data at an open ftp server etc.) is seen as a positive step forward and this protocol should be further extended (e.g., to include more detailed information on the selection criteria for ground-based data, details on how zonal means are being calculated)

b. Information exchange among the European and American ozone satellite providers and retrieval researches should continue as all can learn from each other especially on the error characterization of the different data sets
c. The separate long term American and European total ozone data sets (with clear error characterization) as already provided right now are valuable for the user community (e.g. climate modelers and researchers)
d. As users have different requirements a combined American/European long term data set should be provided as well by the experts on the satellite instruments and the retrieval algorithms as being present at the ACC-9 meeting. For the American data sets, the focus should be on the usage of the SBUV data as they provide a reference data set.
e. Other satellite data sets (e.g. Chinese missions, infrared missions like IASI) should be included into this data intercomparison process and possible merging activities
f. If resources allow, these activities should be extended to nadir ozone profiles covering the time period of the last 15 years.

2. Volcanic Ash Monitoring From Space

   a. Activities in Europe and North America to use space-based observations to monitor volcanic ash, enhance forecasts, and provide products to decision makers and industry were discussed. With the successful conclusion of a workshop held in Dublin in March 2013, ACC meeting participants welcomed enhanced collaboration between the North American and European communities on this topic.

3. Air Quality Constellation Coordination

   a. It was noted that substantial progress has been on two of the three near-term actions of the community white paper, endorsed at the CEOS Strategic Implementation Team (SIT-26) meeting:

      1. Points of contact from each region have been named to participate on mutual mission science or advisory teams with a focus on common science and collaborative data products

      2. The CEOS/MACC-II International OSSE Workshop was held 22-24 October 2012 at ECMWF (http://www.ecmwf.int/newsevents/meetings/workshops/2012/OSSE/) and shared expertise, discussed common approaches and experiments, and defined initial collaboration to share high resolution global chemistry/aerosol nature runs

   b. The third action to coordinate a societal benefit assessment of satellite air quality observations, leveraging recent GCOS and GEO health community of practice efforts, requires interaction with economists and health effects communities.

   c. Following discussion of the status of the upcoming missions, there was consensus on these draft recommendations:

1. Convene (virtually or otherwise) an expert group to develop best-practices recommendations for UV-Vis spectrometer pre-launch instrument characterization

2. Agreed that common absolute radiance calibration is a secondary rather than primary need for these instruments; better to instead invest funds in characterizing each instrument as completely as possible

3. Share our pre-launch calibration plans (to the extent allowed by possible proprietary restrictions) and invite cross participation in reviews that cover calibration

4. Share instrument characterization/calibration databases and Level 1-b data, in a common format, to allow application of common algorithms to all datasets

5. Develop a list of desired constellation data products (which may or may not differ from each mission's standard products)

6. Strive for consistency in retrieval algorithms

7. Cross participation in ATBD reviews

8. Jointly improve retrieval algorithms by conducting inter-comparisons on common radiances

9. Develop longer term recommendations for possible common post-launch calibration/validation (cal/val) strategies (e.g., supersite instrumentation round-robins, joint airborne campaigns)

4. <u>GHG ECV Generation</u>

   a. There are many activities in progress (e.g. JAXA/NIES, JPL, ESA-CCI, EU projects) to further explore SCIAMACHY and GOSAT CH_4 and CO_2 measurements and to demonstrate their usefulness for retrieving information about regional sources and sinks. Data of other satellite measurements that cannot measure down to the Earth's surface (e.g. AIRS, IASI) are also being studied and used to constrain GHG inversion methods.

   b. It was noted that there are several new GHG satellite missions already planned (e.g. OCO-2, GOSAT-2, TanSat, Merlin) and proposed (e.g. Carbonsat).

   c. Meeting attendees decided that it would be beneficial (especially to support future planned GHG satellite missions) to follow the example of the ACC Air Quality Constellation to write a white paper on a similar Constellation for GHG missions with an emphasis on algorithm improvements and uncertainty quantification. A formal timeframe for this activity will be agreed in the near future.

5. It was agreed by meeting attendees that the next ACC meeting should take place during the spring of 2014 at a location in the United States to keep travel costs at a tractable level for participants, particularly from Europe and North America. It was further noted that ACC participation from CEOS-member agencies and related academic institutions in Asia is increasing and a future ACC meeting in Asia would be welcome.

3.0 Summary of Workshop Topics and Discussions

3.1 Introduction

Following an opening address by Alain Ratier, Director General of EUMETSAT, Claus Zehner (ACC Co-Lead, ESA) discussed the scope of the meeting. The goals of the present meeting were:

- A full-day session would be held on total ozone column (TOC) data sets derived from ESA, EUMETSAT, NASA, and NOAA missions (with other associated data sets discussed). Prior to the meeting, a validation protocol was developed. The long-term European and USA total ozone satellite and agreed ground-based data sets were made available on an open ftp server at BIRA/IASB. Points to be considered included:
    - Understand algorithms characteristics of different consolidated USA and European total ozone data sets
    - Gain insight on total ozone satellite retrieval algorithms by comparison to ground-based reference measurements
    - Learn about different ways to create long term total ozone time series (e.g. linking data from different satellites)
    - Discuss merging/combining of European and USA total ozone data sets
    - Discuss possible extensions of this kind of work, to include more total ozone algorithms (e.g. from Chinese missions, IASI) and/or do a similar exercise on nadir viewing profiles

  The desired concrete output of this session would be to make recommendations on the merging/combining of European and USA total ozone data sets.

- On the second day, progress on the monitoring of volcanic ash from space and making these measurements and related forecast products available to decision makers and industry will be discussed.

- Recent results of the ACC Air Quality Constellation, an activity to enhance interagency coordination of forthcoming geostationary missions making measurements relevant to air quality monitoring and forecasting would be discussed, together with a discussion of near-term actions.

- Following on from the discussion at ACC-8, held in April 2012, ACC would consider activities related to the generation of Greenhouse Gas (GHG) essential climate variables (ECVs) and assess relevant current and forthcoming space-based missions.

3.2 Long-Term Total Ozone Column (TOC) Data Sets

3.2.1 Total Ozone Validation database and Protocol (Jean-Christopher Lambert, BIRA-IASB)

It was agreed that the following space-based data sets would be included in the Database: SBUV, OMI, OMPS/nadir, GOME, SCIAMACHY, and GOME-2. Ground-based data from Dobson, Brewer, and DOAS/SAOZ were also included.

The purpose of the validation protocol is to define a restricted set of common validation parameters and analyses. It is anticipated that results obtained by different validation groups using different reference data sets can be better compared and discussed. The specific harmonization points (including binning strategies) and ground-based data stations are described fully in the presentation (available on the ACC website will all other workshop presentations).

3.2.2 New and Updated Ozone Cross-Sections from IUP Bremen (Mark Weber, University of Bremen)

The new Serdyuchenko et al. ozone cross sections are now available. They have broad spectral coverage at many temperatures, with high spectral resolution. As part of the Integrated Global Atmospheric Chemistry Observations (IGACO-O3) Absorption Cross Sections of Ozone (ACSO) activity, thorough testing in the UV/Visible remote sensing community is underway. Details on the ACSO workshop, to be held on 3-5 June in Geneva, may be found at http://igaco-o3.fmi.fi/ACSO/ws_2013.html.

New laboratory measurements are currently being performed to further improve cross sections in the Wulf band (>900 nm) and the absorption minimum region (~370 nm) using an improved FTS setup. Future plans include thermal infrared (TIR) laboratory measurements for improving consistency between IR and UV sensors (e.g., GOME-2 vs. IASI). Satellite FM cross-sections at medium spectral resolution have been significantly improved by reanalysis. It is concluded that satellite FM cross-sections are useful for diagnosing instrument performance (e.g., spectral resolution, SNR, etc.).

3.2.3 Key Features of the Latest Ozone CCI Total Ozone Algorithm (Michel Van Roozendael, BIRA-IASB)

The overall motivation for this study is to demonstrate the new European multi-sensor level-2 and level-3 data sets with improved consistency (targeting compliance to GCOS objectives). Through the ESA ozone_cci project, ozone from the GOME, SCIAMACHY and GOME-2(A) instruments were reprocessed using a common state-of-the-art direct-fitting (scientific) algorithm. A new soft-calibration scheme was employed. Improved inter-sensor consistency was seen, in comparison to the current level-2 data sets.

For the future, the algorithm will be employed with OMI ozone measurements. Plans for CCI Phase-2 include improvement of the cloud correction, improvement of soft calibration, the addition of OMI, a data base update (e.g., TOMS v9), and work on a combined column/profile algorithm.

3.2.4 Chinese Missions for Polar Ozone Depletion Monitoring (Fuxiang Huang, National Satellite Meteorological Center)

In recent years, China has studied polar ozone depletion using both space and surface-based observations. Surface observations from Zhongshan began in 1993. Studies of the 2011 spring Arctic ozone depletion were made with data from the FY-3B SBUS, FY-3A TOU, as well as from NOAA-16, 17, 18 and 19 SBUV/2. Comparison of ozone profiles from the FY-3B SBUS in the Arctic prior, during, and after the depletion event reveals that 77-83% of the total ozone decrease comes from the atmosphere located at heights of 100-10 hpa.

Uncertainties in satellite monitoring data have been considered, particularly with respect to the presence of PSCs and their impact on ozone retrievals. CALIPSO is helpful to understand PSCs, but there is still much work to do to understand the impact of PSCs on retrievals. Theoretical simulations have shown that ozone retrieval error can be as large as 20-30 DU for some vertical layers, or 20-50% for the total ozone column.

Most present BUV algorithms are unable to deal with PSCs correctly. New algorithms to improve ozone retrievals to monitor polar ozone loss are needed.

3.2.5 GOME-Type Total Ozone (GTO) Instrumental Differences Found/Solved (Diego Loyola, DLR)

Inter-Satellite Calibration was investigated. One data set was selected as a reference (GOME) and the other sets were (SCIAMACHY and GOME-2) corrected for spatial and temporal biases and drifts. The GDP4.6 algorithm is operational for SCIAMACHY and GOME-2 (Metop-A & B) and there are several journal papers describing it (e.g., Van Roozendael et al., JGR 2006, Loyola et al., JGR 2011, D. Balis et al., JGR 2007, and Koukouli et al., AMT 2012)
The GODFIT ESA CCI algorithm is described in the Van Roozendael et al. paper (JGR 2012).

Self-consistent and independent long-term datasets started in 1995. Ground-based data is used for geophysical validation. The merged product is used for climate model evaluation.

The results of merging GDP4.6 and GODFIT and a comparison with SBUV v8.6 results were also examined.

3.2.6 EU/US Total Ozone Column Brewer Intercomparison (Jean-Christopher Lambert, BIRA-IASB)

This talk was the first of three examining intercomparisons between the US and European TOC data sets and ground based measurements. This presentation examines the Brewer data set. Total ozone column data records from both the EU (ERS-2GOME, Envisat SCIAMACHY and MetOp-A GOME-2 reprocessed with GODFIT v3 (Ozone_cci)) and from the US (Aura OMI v8.5, NPP OMPS PGE 1.0; SBUV merged NOAA satellites v8 (integrated profile)) were used in the study. The methodology followed the ACC-9 Protocol (described above). Brewer stations were selected subject to a direct sun-only criteria with $\mu < 3.5$. A station-by-station validation/verification process was made, assessing the following quantities:

- Time dependence
- Latitude dependence
- SZA dependence
- Cloud dependence
- Ozone column dependence
- Temperature dependence

A detailed summary can be found in the archived presentation. Key points were that no drift over the period was found with respect to Brewer for any of the instruments studied. Mean bias was typically less than 1%, except -2% for OMI. The ozone column dependence exhibited a more complicated behavior.

3.2.7 Satellite Total Ozone Column Intercomparison against the WOUDC Dobson Network (MariLiza Koukouli, Aristotle University of Thessaloniki)

The main aim of this validation exercise was to assess the potential of the different TOC datasets as input to a common European/American (or American/European) merged TOC dataset. One key conclusion is that the OMI/Aura OMTO3 (v8.5) data constantly underestimate TOC compared to the other datasets. It is recommended that examining in more detail into the OMI/Aura OMDOA3 (v8.5) data would be useful. Other findings include:

- Suomi NPP OMPS data follows quite closely the GOME1/SCIA/GOME2 triad.
- No seasonal variability in any dataset (apart from BUV/4)
- SZA variability within ±2% for all sets (apart from BUV/4).
- A slight positive "bump" appears for columns around 200-250 D.U. for all datasets. Explanation is not clear. Could this be a transition from hole conditions to normal conditions or other polar vortex issues? Sampling issues are also not excluded as culprits.
- For the GOME1/SCIA/GOME2 triad the known Dobson instruments' effective temperature dependency is confirmed for the GODFIT v3 algorithm as well. It might be responsible for most of the lingering SZA effects still seen.

3.2.8 Satellites SAOZ Total Ozone Comparisons (Jean-Pierre Pommereau, LATMOS)

Satellites with overpasses above Systeme d'Analyse par Observation Zenithale (SAOZ) stations were considered in the comparisons. These include: TOMS V8 (1995-2005), SBUV (1995-2012), GOME (1995-2003 Europe, 1995-2003 all), GOME2 (2007-2012), SCIAMACHY (2002-2012), NPP (2012), OMI-TOMS (2005-2012), OMI-DOAS (2005-2012). For SAOZ observations, relevant parameters include zenith sky at twilight 86-91° SZA, visible Chappuis bands. The version 2 retrieval follows the NDACC working group recommendations (i.e., daily air mass factors from the TOMS V8 ozone profiles climatology). Comparisons were performed only after 1995, because of perturbation by Pinatubo volcanic aerosols.

The most influential parameters on differences between satellites and SAOZ include:

- Temperature and SZA dependences of satellites retrievals (the relative contributions difficult to separate due to identical seasonality). This is seen principally with TOMS V8, and OMI-TOMS, but less for the others (SBUV, GOME, GOME2, SCIAMACHY, NPP)
- Stratospheric ozone profile longitudinal variation is most significant in polar areas
- Tropospheric ozone longitudinal variation ghost correction for cloud fraction is most significant over the intertropical convergence zones and very cloudy areas

A major improvement of satellites and SAOZ total ozone retrievals is anticipated from the use of a 2-D profile climatology that includes tropospheric ozone.

3.2.9 Key Features of the SBUV version 8.6 Total Ozone Algorithm (Rich McPeters, NASA)

A coherent, trend-quality 41-year ozone time series has been produced using BUV and SBUV instruments dating back to Nimbus 4. The v8.6 retrieval algorithm is optimized for retrieving monthly zonal mean profiles, with an a priori (ozone & temperature) based on climatology. A Rodgers optimal estimation approach is employed using wavelengths from 252 nm – 306 nm (+ 312 and 317 nm at high SZA). The resolution varies from ~6 km near 3 hPa to ~15 km in lower stratosphere. A key finding is that the total column O_3 from an integrated profile is more accurate than TOMS.

Data are available from the Goddard DISC in monthly zonal mean profiles (hdf5 format). Individual retrievals are in preparation. The website is http://disc.sci.gsfc.nasa.gov/daac-bin/DataHoldingsMEASURES.pl.

An anonymous ftp site is also available providing monthly zonal mean profiles and individual retrievals (profiles only) in ASCII format at ftp://toms.gsfc.nasa.gov/pub/sbuv.

The v8.6 ozone data has been released as a NASA MEaSUREs data set and includes Nimbus 4, Nimbus 7, NOAA 9, 11, 16, 17, and 18. Nimbus 7 TOMS, Earth Probe TOMS and OMTO3 will be processed as version 9.

Key conclusions from the v8.6 algorithm include a 4% global ozone decrease since 1979/1980, but no significant trends in the equatorial zone. The accuracy of the SBUV time series appears to be better than that of the ground network normally used for validation. Column ozone above 101 hPa (global average) is consistent with Aura MLS and with SAGE II at the 1% to 2% level (but with an offset).

3.2.10 Key Features of the Latest TOMS Total Ozone Algorithm (David Haffner, SSAI)

The objectives for the v9 TOMS retrieval algorithm are to:

- Provide Error Bars to users (which is a frequent request)

- Supply information to estimate systematic error (to provide the correct layer Efficiency Factors (EF))
- Extend retrievals to 88° SZA
- Simplify the entire algorithm
- Provide quality as good as V8, within error bars
- Rodger's Optimal Estimation is a natural choice: it was originally considered just for high SZA, but was found to work well elsewhere

Key conclusions from the analysis include:

- V9 TOMS is in good agreement with V8 TOMS. Compares well with V8.6 SBUV.
- Retrievals extended to 88° SZA.
- Errors originate mostly in lower atmosphere where Rayleigh scattering limits retrieval of O_3 information (significant at high SZA, i.e. O_3 hole).
- V9 provides consistent profiles.
- Algorithm offers flexibility.

3.2.11 Instrument Issues Addressed in the Creation of SBUV V8.6 Ozone Data (Matthew DeLand, SSAI)

The BUV and SBUV instruments have measured total ozone and profile ozone since 1970 (continuously since November 1978). Nine separate instruments are represented in this data set, with very similar designs, but unique characteristics and on-orbit behavior. A consistent calibration and accurate on-orbit characterization is needed to produce data sets that can be used for trend studies. Overlapping temporal coverage is valuable, but drift in sun-synchronous orbit complicates our analysis. More details on many topics in the recent paper: DeLand et al. (2012), Atmos. Meas. Tech. 5, 2951-2967.

A detailed study of the issues is found in the archived presentation. Key conclusions of the analysis include:

- Creation of a coherent SBUV V8.6 data set benefits from common instrument design and temporal overlap
- Develop calibration adjustments based on measured quantity (radiances), rather than retrieved product (ozone).
- Create empirical corrections when consistent parameterization (e.g. Nimbus-7 hysteresis) can be developed.
- Establish reference data set(s) as basis for intercalibration.
- Select measurements with similar characteristics for determination of inter-instrument adjustments.

3.2.12 Satellite to Satellite Intercomparisons: Comparisons of SBUV Total Column Ozone Values to those from GOME, GOME 2, OMI & SCIA (Gordon Labow, SSAI)

Detailed analysis is found in the archived presentation. Among the preliminary conclusions is that the agreement at equatorial zones looks reasonably good. In addition, the mid-latitude comparisons look reasonably good. Trends & Offsets are all within ~+/-1%. But, the high latitudes are problematic.
Also noted are issues with the seasonal cycle. GOME has noise issues after 2006.

3.2.13 Using data assimilation to combine TOC data sets: The Multi-Sensor Reanalysis (MSR) ozone data record (Ronald van der A, KNMI)

The underlying assumption used is that the ground observations are on average a good approximation for the truth. The procedure for the combination process was that UV-VIS satellite data (TOMS, SBUV, GOME, SCIAMACHY, OMI, GOME-2) in the period 1978-2008 is used. The first step was to correct satellite data to avoid biases. The reference data that is chosen are ground data observations from reliable WOUDC stations. Then, satellite data was assimilated in a chemical-transport model to achieve complete global and temporal coverage. The version 1Multi Sensor Re-analysis (MSR) is available at http://www.temis.nl. Details may be found in the paper: R.J. van der A , M.A.F. Allaart and H.J. Eskes, Multi sensor reanalysis of total ozone, Atm. Chem. Phys., 2010, 10, 11277-11294.

Comparison to AC&C/SPARC is in general good agreement. There are zonal differences at mid-latitudes that are related to high UT/LS variability. Polar differences are due to sparse satellite data and data assimilation in polar night.

Version 2 of the MSR for the period 1970-2012 is in development. We are assessing the method to apply to ozone profiles, but the bias correction is much more complicated. While the algorithm for data assimilation of profiles is available (e.g., O_3_cci), the vertical distribution still has to be validated especially for long assimilation runs.

3.2.14 An approach to combine USA/European TOC (Diego Loyola, DLR)

A recommendation from climate modelers in the Ozone CCI for combining SBUV and GTO data sets is to use only measurements, and not models, for generating the ECVs

An ensemble combination between SBUV and GTO provides independent datasets and good agreement. The underlying motivation would be to improve spatial coverage and reduce the variance. Illustrative examples are found in the archived presentation.

3.2.15 Discussion on possibility to combine USA/European TOC ECV (All, led by Claus Zehner)

- The setting up of a common validation protocol for the ACC-9 total ozone workshop (all using the same reference data for validation, availability of all data at an open ftp server etc.)

is seen as a positive step forward and this protocol should be further extended (e.g., to include more detailed information on the selection criteria for ground-based data, details on how zonal means are being calculated)

- Information exchange among the European and American ozone satellite providers and retrieval researches should continue as all can learn from each other especially on the error characterization of the different data sets
- The separate long term American and European total ozone data sets (with clear error characterization) as already provided right now are valuable for the user community (e.g. climate modelers and researchers)
- As users have different requirements a combined American/European long term data set should be provided as well by the experts on the satellite instruments and the retrieval algorithms as being presented at the ACC-9 meeting. For the American data sets, the focus should be on the usage of the SBUV data as they provide a reference data set.
- Other satellite data sets (e.g. Chinese missions, infrared missions like IASI) should be included into this data intercomparison process and possible merging activities
- If resources allow, these activities should be extended to nadir ozone profiles covering the time period of the last 15 years.

3.2.16 From IASI to IASI-NG: Ozone (Cathy Clerbaux, LATMOS)

The aims of the IASI mission are (1) Meteorology (improved weather forecasting), (2) Atmospheric composition (climate gases monitoring and understanding atmospheric chemistry), and (3) Operational applications (e.g., fires detection, volcanic plumes with a time resolution of ~2.5 hours).

A detailed comparison of IASI O3 results with other satellites and sondes is found in the archived presentation. Availability of the Forli O3-IASI data generated at Latmos/ULB will be available in NRT through Eumetcast in 2014. Prior to that, data are available on ftp upon request, for selected zones and or times.

IASI-NG has the potential for strongly benefiting the NWP, chemistry, and climate communities, in addition to assuring the continuity of high quality observations delivery.

3.3 Volcanic Ash Monitoring From Space

3.3.1 Monitoring Volcanic Ash from Space: Activities at the European Space Agency (Claus Zehner, ESA)

There was an extension of the ongoing activities of the three projects during 2012:

1. VAST (http://vast.nilu.no/) a three-year project lead by NILU (F. Prata)
2. SACS2 (http://sacs.aeronomie.be) an 18-month project lead by BIRA/IASB (N. Theys)
3. SMASH – based on the EU European Volcano Space Services (EVOSS) Project (http://www.evoss.eu) an 18-month project lead by CGS (L. Tampellini)

The goals of these projects are to enhance the usage of EO satellite data for volcanic ash monitoring, update existing user requirements, Provide improved satellite based volcanic emission information based on, e.g., SEVIRI, AATSR, MODIS, GOME2, IASI, OMI, AIRS measurements, provide improved eruption source information, establish an operational LIDAR network in Ireland (national co-funding), establish a database for historic eruptions (satellite, ground-based, airborne, modeling data), develop of an operational demonstration volcanic ash forecasting service (open source code operated at ZAMG) that could be implemented at VAACs or elsewhere, and define a "best" future end-to-end volcanic ash monitoring system.

An ESA/EUMETSAT volcanic ash and aviation user workshop was held in Dublin on March 4-6, 2013, with ~50 participants from the research, forecasting, industry, and regulatory communities. Details may be found at http://vast.nilu.no/UserWorkshop/tabid/10873/Default.aspx. Some key points raised included consideration of an Eyjafjoll–like eruption tomorrow. Would the situation today different as compared to the one in 2010? With respect to user Requirements, what has changed during the last 3 years? Interaction between observations and models was considered and priorities for future actions were assessed (EU - Horizon 2020).

There is extensive interaction and complementarity among the three projects:

- All three projects have the same Technical Officer from ESA
- Exchange of expertise and results: The AIRS algorithm of F. Prata (VAST) has been implemented recently into the SACS web-based warning system
- Different consortia include different satellite retrieval experts (e.g. SEVIRI - NILU, AATSR –FMI, IASI – ULB, MODIS - INGV) and background knowledge
- There are complementary approaches being developed on the derivation of improved eruption source information
- All three projects will provide input data to a volcanic eruption database (e.g. SMASH: INGV Etna ground-based data)
- SACS and NILU satellite products will feed into an operational demonstration volcanic ash forecasting service
- The SMASH consortium will define a 'best' future end-to-end volcanic ash monitoring system in Europe

3.3.2 EUMETSAT Volcanic Ash Products (Marianne König, EUMETSAT)

Following the 2010 Eyjafjalla eruption, EUMETSAT was tasked to make a volcanic ash product operationally available, using the MSG-SEVIRI satellite information. A volcanic ash retrieval algorithm was developed through a scientific collaboration with Dr. Fred Prata (NILU). The product is operationally available since May 2012. Several areas of improvement are identified and will be worked on in the future (initial ash detection, algorithm change to a full optimal estimation type of approach).

The SEVIRI Volcanic Ash Product is available in netCDF format (with ash effective radius, mass loading, height (incl. quality) per pixel) – 96 times per day. In case of a significant event (upon request from the London VAAC), the following products will be available: CAP (Common Alert Protocol) format. Text files, images (PNG format). No full validation of the operational product has been done yet. Satellite products should always be used in combination with other information!

For the future, SEVIRI ash detection must address the problem that reliable ash detection is still a problem. Improvements and tests are ongoing. There is collaboration with the UK Met Office (Peter Francis) and Fred Prata. There are plans to investigate all volcanic eruptions in the Meteosat FOV and use two Meteosats for stereo height assignment. There are also plans for including the detection of SO_2.

We will explore the potential of an optimal estimation approach (which is promising, especially in the case of ash above lower clouds).

The Meteosat Third Generation (MTG) will include a sounding satellite, carrying an Infrared Sounder. Volcanic ash products from the sounder will be similar to what is currently available for, e.g., IASI. The Imager satellite will be launched in Dec 2018 (similar to MSG, improved spatial/temporal resolution, more shortwave channels). A Sounding satellite will be launched 2 years later.

3.3.3 NASA Activities on Volcanic SO_2 and Ash (Jay Al-Saadi for Nicholas Krotkov, NASA)

The NASA Applied Sciences Program Disaster Management element supports the production of near real time volcanic SO_2 and ash data and their integration in aviation decision support systems, e.g., for VAACs. The NASA A-train formation of polar satellites provide multiple instruments capable of observing volcanic clouds gases and aerosols: Aqua/MODIS for Vis + Thermal IR (TIR), Aura/OMI for SO2 + aerosol Index (dust, ash), and CALIPSO/CALIOP lidar for ash vertical profile. Unique discrimination of volcanic clouds is possible ONLY with UV or TIR measurements.
The NASA project continues collaboration with NOAA and other partner organizations to fully utilize and disseminate NASA SO_2 and ash volcanic data to further improve their decision support system (DSS) for early warning. The products will be enhanced with Aqua/AIRS data

and continued using new SO_2 and ash data from the next generation operational NPP/JPSS sensors.

The value of increased observational frequency of polar orbit swath overlaps, together with reduced satellite data latency times (to 20 minutes by utilizing direct broadcast data received at ground stations in Finland and Alaska) is currently being demonstrated. Given a new emphasis on quantitative ash mass forecasts for air traffic management (ATM) we propose utilizing satellite data assimilation techniques in a NASA global model to demonstrate improved medium range forecasts of volcanic cloud location and vertical extent. Metron Aviation's experience in developing ATM DSS for use by the FAA, airlines and other key players will be used to help shape satellite products. This will ensure that they are relevant and more readily transitioned into operational use.

3.4 THE ACC Air Quality Constellation

3.4.1 The ACC Air Quality Constellation (Jay Al-Saadi, NASA)

The geostationary orbit provides "continuous" observations (many times per day), but a single geostationary satellite can view only a portion of the globe. Several countries and space agencies are planning to launch geostationary satellites in the 2017-2022 time frame to obtain air quality measurements. These missions share common objectives yet individually are restricted to regional relevance. Harmonization through a constellation framework will provide a global perspective otherwise impossible to achieve.

This Constellation coordination activity is focused on collaboration to improve and extend data utilization from the planned missions. The missions now funded are Europe (Sentinel-4), Korea (GEMS), and the US (TEMPO). These missions will enable the "baseline" constellation data products. In addition, the Europe Sentinel 5 Precursor TROPOMI, planned for a low Earth orbit, is participating in the coordination efforts. The ongoing retrieval algorithm and chemical OSSE collaborations will be continued. It's important to assess possibilities for common instrument pre-launch characterization and instrument calibration, perhaps through a workshop next year.

The activity also provides a framework for fully implementing the space component of an integrated observing system for air quality as envisioned in international protocols and conventions (IGACO, GEO, WMO GAW, and UN CLRTAP). Additional goals include:

- Consideration of extending capability based on the "goal" constellation data products;
- Assessing candidate measurement requirements for missions with still-open payload details (e.g., GEO-CAPE, GMAP-ASIA) and developing suitable concepts for filling these gaps;
- Extending observational coverage, including to the Southern hemisphere;
- Considering copies of instrument designs to lower per-instrument cost; and
- Considering possible launches as commercially hosted payloads to reduce mission cost.

The recently initiated chemical OSSE collaboration will develop capability to quantitatively assess candidate measurements for such extension of capabilities.

Proposed next steps:

- Develop a plan, with specific and realistic recommendations to our agencies
    - Identify what constellation products and common activities are desired. Is it useful to have standard Level 1 products and databases that are easily exchanged? Consistent standard L2, L3 products vs. special constellation products. Consistency of spectroscopy, cal/val and field campaign needs, sharing of algorithms, sharing scientific results
    - Identify how to attain these recommendations – what key steps
    - Identify collaboration that is already occurring vs. new collaboration needed
    - Prioritize: which new collaborations need attention sooner and which can wait till later

- Emphasize that shared instrument characterization and calibration databases are critical to any form of constellation product
- Define to what extent it is desirable to standardize content and formats of the characterization/calibration databases to be shared
    - Are there similar priorities for the parameters and values in the test matrices?
    - If an instrument test program has to be reduced, help avoid de-scoping something that may be critical to a constellation product
    - Some dependence on particular instrument design and retrieval approach

The community-developed position paper, endorsed at CEOS SIT 26, is available at http://www.ceos.org/images/ACC/AC_Geo_Position_Paper_v4.pdf

3.4.2 Tropospheric Emissions: Monitoring of Pollution (TEMPO) (Kelly Chance, SAO)

TEMPO was selected in November 2012 through NASA's first Earth Venture Instrument solicitation. Instrument delivery is planned for September 2017. NASA will arrange hosting on commercial geostationary communications satellite with expected ~2019 launch. TEMPO will provide hourly daylight observations to capture rapidly varying emissions & chemistry important for air quality. A UV/visible grating spectrometer to measure key elements in tropospheric ozone and aerosol pollution exploits extensive measurement heritage from LEO missions. It will distinguish the boundary layer from free tropospheric & stratospheric ozone. The mission is aligned with Earth Science Decadal Survey recommendations, makes most of the GEO-CAPE atmosphere measurements, and responds to the phased implementation recommendation of GEO-CAPE mission design team. TEMPO will serve as the North American geostationary component of an international constellation for air quality monitoring.

Standard data products are NO_2, O_3, aerosol, and cloud products sampled hourly, including eXceL O_3 for selected target areas; H_2CO, $C_2H_2O_2$, and SO_2 sampled 3 times/day (hourly samples averaged to get S/N). Product spatial resolution will be ≤ 8 km N/S × 4.5 km E/W at the center of domain. Measurement requirements will be met up to 70° SZA for NO2, 50° for other standard products.

TEMPO will be placed into a geostationary orbit, operating on a commercial telecom satellite. NASA will arrange launch and hosting services (per Earth Venture Instrument scope): 90-110° W preferred, while 80-120° W would be acceptable. Hourly measurement and telemetry duty cycle for ≤70° SZA with plans to measure 20 hours/day. TEMPO is low risk with significant space heritage since all proposed TEMPO measurements have been made from low Earth orbit satellite instruments to the required precisions and all launch algorithms are implementations of currently operational algorithms. Measurements include NASA TOMS-type O_3, SO_2, NO_2, H_2CO, $C_2H_2O_2$ from AMF-normalized cross sections.

TEMPO research products will greatly extend science and applications. Example research products include profile O_3 for broad regions, BrO from AMF-normalized cross sections, height-resolved SO_2, additional cloud/aerosol products, and vegetation products. Example higher-level products include pollution/AQ indices from standard products and city light maps.

3.4.3 The Sentinel-4 Mission: Instrument Description and Atmospheric Composition Products (Ben Veihelmann, ESA)

Sentinel-4 will include a UVN spectrometer on EUMETSAT's Meteosat Third Generation Sounder (MTG-S) platforms with launch of the first platform in 2019; utilization of data from the InfraRed Sounder (IRS) on MTG-S, and utilization of data from the Flexible Combined Imager (FCI) on the MTG Imager (MTG-I) platforms. The Sentinels are a key contribution to the space component of the EU Global Monitoring for Environment and Security (GMES) program. Key features of this geostationary constellation are hourly revisit time over Europe, mainly for air quality applications and the study of the diurnal cycle of tropospheric composition.

Sentinel-4 is well suited to meet user requirements for observations of NO_2, O_3, HCHO, and SO2 in clear or partially cloudy conditions. The aerosol optical thickness user requirement will be achieved (at full spatial sampling) only in slant viewing and illumination conditions. Several observations per day are likely due to hourly revisit time. The team is participating in Observation System Simulation Experiments (LEO + GEO) through the ISOTROP study with KNMI, CNRS, TNO, FMI, and NILU.

The Instrument Preliminary Design Review has been completed, with the mission now in Phase C/D. L1 processor development is in preparation, while L2 pre-development is ongoing, with studies of both the aerosol profile retrieval from O2A-band and surface reflectance map from temporally aggregated S4 data. The L2 processor development is in preparation, with the ITT by the end 2013 and an anticipated kick-off in early 2014.

3.4.4 Status of GEMS Program (Jhoon Kim, Yonsei University)

Geo-KOMPSAT-2A and 2B are expected to be launched in the 2017-2018 time frame and provide information on aerosol and trace gas amounts with the three instruments of AMI, GOCI-2 and GEMS. GEMS, a geostationary mission, is expected to contribute monitoring air quality and short-lived climate forcers (SLCFs) in Asia in high temporal and spatial resolution. Using a scanning UV-Visible spectrometer, its observations can contribute to provide a set of tropospheric column products over the Asia-Pacific region at spatial resolution of ~ 8 km and temporal resolution of 1 hour. Other products include NO_2, HCHO, SO_2, and aerosol optical depth.

GEMS will contribute to the understanding of the globalization of pollution events, source/sink identification, and long-range transport of pollutants and SLCF, as a part of the activities of the CEOS ACC.

3.4.5 Sentinel 5 Precursor (Pepijn Veefkind, KNMI)

The ESA Sentinel-5 Precursor (S-5P) is a pre-operational mission focusing on global observations of the atmospheric composition for air quality and climate. The TROPOspheric Monitoring Instrument (TROPOMI) is the payload of the S-5P mission and is jointly developed by The Netherlands and ESA. The planned launch date for S-5P is 2015 with a 7 year design lifetime.

The science objectives of TROPOMI are to better constrain the strength, evolution, and spatiotemporal variability of the sources of trace gases and aerosols impacting air quality and climate, to improve upon the attribution of climate forcing by a better understanding of the processes controlling the lifetime and distribution of methane, tropospheric ozone, and aerosols, to better estimate long-term trends in the troposphere related to air quality and climate from the regional to the global scale, and to develop and improve air quality model processes and data assimilation in support of operational services including air quality forecasting and protocol monitoring.

S5P TROPOMI will be a major step forward for atmospheric composition observations due to improved spatial resolution & sensitivity. S5P will connect the geostationary UVN missions: Sentinel-4, GEMS and TEMPO. The Level 2 products are developed by an experienced team of European institutes. For the validation of the L2 products campaigns are needed that focus on challenging conditions.

3.4.6 A global GEO OSSE Activity for CEOS (David Edwards, NCAR)

Observing System Simulation Experiments (OSSEs) have been extensively used by the NWP community in order to help develop and optimize contemporary meteorological satellite instruments. OSSEs are now also increasingly used in other fields of earth observation. OSSEs assess the impact of hypothetical observations on a model analysis/forecast/inversion and provide a means to generalize on the limited conclusions of case-studies. The CEOS ACC whitepaper, "A Geostationary Satellite Constellation for Observing Global Air Quality: An International Path Forward" called for "(OSSE) cooperation to define, conduct, and analyze common scenarios ….align and extend the ongoing regional studies and to systematically incorporate them into global studies."

A CEOS/MACC-II International chemical OSSE Workshop was held at ECMWF in October 2012 attracting 30 participants sharing expertise toward developing common approaches and experiments. The meeting aimed at reviewing experience from NWP, reporting on existing work worldwide on OSSEs for "chemical" satellite instruments, discussing best practices and defining needed infrastructure in order to set up reliable experiments. The workshop's goal was to define experiments to document the impact of GEO instruments alone, together over different parts of the globe, and in conjunction with LEO assets.

OSSEs need to account for realistic atmospheric variability. This requires evaluation of the nature run (NR) with observations. OSSEs require realistic variability in measurement simulations generated from NR which requires incorporation of sensitivities due to cloud, aerosol, trace gases, surface UV-visible reflectivity, and IR emissivity. Simulated retrievals must include realistic range of sensitivities. OSSEs for relative performance between instruments/viewing scenarios may be more reliable. If comparing a next generation system , we need high accuracy and full system evaluation with the existing observing system. From NWP experience, OSSE-based decisions have international stakeholders; experiments should therefore be developed as joint global projects. Community ownership and oversight of OSSE capability is also important for maintaining credibility.

3.4.7 GEO Air Quality (AQ) Community of Practice (CoP) Activities and Atmospheric Composition Metadata (Martin Schultz, Forschungszentrum Jülich)

The GEO AQ CoP was initiated in 2005 via the NASA REASoN program, which maintained a requirement to participate in ESIP and NASA Earth Science Data Systems Working Group. The objective of the ESIP Air Quality Workgroup was to connect air quality data consumers with the providers of those data by bringing people and ideas together on how to deliver Earth Science data to AQ researchers, managers and other users and to facilitate and demonstrate the information flow among data providers to air quality consumers.

A formal connection to GEOSS resulting in 2008. The Task Force on Hemispheric Transport of Air Pollution (TFHTAP) initiative served as a breeding ground for activities. Two practitioner workshops have been held (in 2011 and 2012). And, there have been stronger European contributions since 2011 (MACC-related).

For the future, the GEO AQ CoP needs to redefine itself and ensure broad community support. The metadata (vocabulary) discussion should be continued in the GEO AQ CoP framework, because it offers a truly global perspective. It is important to continue efforts to build a functional data network (important side aspect: NRT and archived data needs). Maintaining efforts to build up trust within the multi-faceted air quality and atmospheric composition community is also important and requires a careful balance between large and small actors, operational and research agencies, geographic regions, etc. There is also a need to identify and realize specific projects which further develop servers, protocols, metadata, and connections (which requires additional funding).

3.4.8 Introducing GSICS and the Potential UV Sub-Group (Tim Hewison, EUMETSAT)

The Global Space-based Inter-Calibration System (GSICS) is an initiative of CGMS and WMO to produce consistent, well-calibrated data from the international constellation of Earth Observing satellites. The GSICS strategy is to improve on-orbit calibration by developing an integrated inter-calibration system, initially for GEO-LEO Inter-satellite calibration, but to be extended to LEO-LEO using external references as necessary, and employing the best practices for prelaunch characterization (with CEOS WGCV).

This will allow us to improve consistency between instruments, reduce bias in Level 1 and 2 products, provide traceability of measurements, retrospectively re-calibrate archive data, and better specify future instruments.

Since 2012, GSICS product development includes corrections for GEO-LEO IR which is now pre-Operational for Meteosat (EUMETSAT) & GOES (NOAA), nearly pre-operational for MTSAT (JMA) and using MetopA/IASI as reference. GSICS Products for GEO-LEO VIS include Deep Convective Clouds (DCC), Ocean Targets (Rayleigh scattering), and Lunar and other methods (deserts, liquid water cloud, etc.)

For 2013, GSICS will provide corrections for GEO-LEO IR, in operational mode for Meteosats, GOES & MTSAT, prototype for other GEOs, delta correction to transfer MetopA/IASI to MetopB/IASI, and quantify diurnal cycle uncertainties. GSICS Products for GEO-LEO VIS will include a demonstration mode of the Deep Convective Clouds (DCC), prototypes for the Lunar target and Ocean Targets (Rayleigh Scattering) + LEO-LEO.

3.4.9 First Steps toward AQ Constellation Calibration/Validation: Pre-Launch Instrument Characterization Activities (Jay Al-Saadi for Scott Janz, NASA)

Based on the longer-term recommendations from the community paper, it's important to agree on an open data policy for AQ-relevant data and support establishment of common cal/val standards. Data sharing protocol should include Level 1-B data to enable reprocessing of all data with common algorithms. Recommendation #4 also stated the need to hold a workshop to compare cal/val plans and identify collaborative opportunities and to strive for common pre-launch instrument characterization and to continue exploring potential common validation instrumentation and collaboration on coordinated ground/airborne validation campaigns, e.g. DISCOVER-AQ, ClearfLo, etc.

Instrument cal/val involves several steps: pre-launch instrument characterization (calibration and verification), in-orbit calibration (e.g., solar and dark cals), and validation of L1, L2 products.

Now is the right time to focus on the pre-launch activities which involves identifying any specific characterization needs for enabling constellation products, while there is still time to implement them. We probably have to consider dependence on retrieval algorithms too.

During this pre-launch period, calibration and characterization database necessary for Level 0 to 1 and 1 to 2 processing of the spectrometer data is needed. This provides verification that instrument meets performance requirements. Typically, this is very focused on retrieval products and their wavelengths. While ACC has no role in defining this, we can perhaps advocate open sharing. In addition, characterization of instrument performance (e.g., slit function, stray light sensitivity, polarization sensitivity) is needed. Here, ACC can coordinate common practices necessary for constellation products.

Recommended next steps include (1) development of a plan, with specific and realistic recommendations to our agencies that will identify what constellation products and common activities are desired, identifying how to attain these recommendations – what are the key steps, and identifying collaboration that is already occurring vs. new collaboration needed; (2) emphasize that shared instrument characterization and calibration databases are critical to any form of constellation product; and (3) define to what extent it is desirable to standardize content and formats of the characterization/calibration databases to be shared .

3.4.10 Discussion on the Air Quality Constellation (All; Jay Al-Saadi, lead)

Following discussion, there was consensus on these draft recommendations:

- Convene (virtually or otherwise) an expert group to develop best-practices recommendations for UV-Vis spectrometer pre-launch instrument characterization

- Agreed that common absolute radiance calibration is a secondary rather than primary need for these instruments; better to instead invest funds in characterizing each instrument as completely as possible
- Share our pre-launch calibration plans (to the extent allowed by possible proprietary restrictions) and invite cross participation in reviews that cover calibration
- Share instrument characterization/calibration databases and Level 1-b data, in a common format, to allow application of common algorithms to all datasets
- Develop a list of desired constellation data products (which may or may not differ from each mission's standard products)
- Strive for consistency in retrieval algorithms
- Cross participation in ATBD reviews
- Jointly improve retrieval algorithms by conducting inter-comparisons on common radiances
- Develop longer term recommendations for possible common post-launch cal/val strategies (e.g., supersite instrumentation round-robins, joint airborne campaigns)

3.5 Greenhouse GAS ECV Generation Activities

3.5.1 The GHG-CCI project of ESA's Climate Change Initiative: Overview and Status (Claus Zehner, ESA)

CO_2 and CH_4 are the two most important anthropogenic greenhouse gases and increasing concentrations result in global warming. Reliable climate prediction requires a good understanding of the natural and anthropogenic (surface) sources and sinks of CO_2 and CH_4. A better understanding requires appropriate global observations and (inverse) modelling. The GCOS Implementation Plan (GCOS-154) notes that "retrievals of greenhouse gases, such as CO_2 and CH_4, of sufficient quality to estimate regional sources and sinks" are needed to construct GHG ECVs.

The GHG-CCI project has made considerable progress in gathering user requirement and comparing algorithms and products. A round robin validation at TCCON sites yielded key results for SCIAMACHY XCH_4, GOSAT XCH_4, SCIAMACHY XCO_2, and GOSAT XCO_2. The generation of a Climate Research Data Package (CRDP) has been completed during these phase 1 activities. The CRDP will be available publicly by September 2013, but is now available upon request (http://www.esa-ghg-cci.org/?q=node/84). Several recent peer-reviewed publications have demonstrated GHG-CCI scientific progress using SCIAMACHY, ENVISAT, TANSO, and GOSAT measurements of XCO_2 and XCH_4.

3.5.2 GHG ECV Generation Activities at NASA and NOAA (Annmarie Eldering, NASA JPL)

NASA's Orbiting Carbon Observatory (OCO-2) will "lead" the A-Train in the slot just ahead of GCOM-W1 with a launch planned for July 2014 using a Delta II launch vehicle. OCO-2 is designed to return space-based measurements of atmospheric CO_2 with the sensitivity, accuracy and sampling density needed to quantify regional scale carbon sources and sinks and characterize their variability.

CO_2 sources and sinks must be inferred from spatial variations in the (>380 ppm) background CO_2 distribution with largest variations near surface. Space-based NIR measurements constrain column averaged CO_2 and XCO_2. High precision is essential to resolve small (<2%) spatial variations in XCO_2. OCO precision will be <0.3% (1 ppm) verified at validation sites seasonally (with over 100 soundings).

The Japanese GOSAT satellite is measuring over the same spectral region as OCO-2 with an FTS (TANSO-FTS). These measurements are being processed through the OCO-2 retrieval algorithm. A critical element of the validation strategy was the Total Carbon Column Observing Network (TCCON). High resolution FTS's measure the absorption of direct sunlight by CO_2 and O_2, in the same spectral regions used by the TANSO-FTS. We are now comparing the ACOS XCO_2 from GOSAT measurements with the TCCON validation data.

OCO-3 on ISS has proposed to advance carbon cycle science and build on the capability to determine regional sources and sinks, provide XCO+ data bridging the potential gap between the OCO-2 and ASCENDS missions, with highest data density at mid-latitudes, reduce errors of the carbon cycle flux in the terrestrial biosphere with measurements of XCO_2 and chlorophyll fluorescence across all sunlit hours, investigate the small scale patterns of ocean carbon flux suggested by eddy-resolving models with dense sets of glint XCO_2 measurements, and detect and quantify the spatial variability of fossil fuel emissions in rapidly developing urban centers as opportunistic science. OCO-3 transitioned into Phase-A in Nov 2012, and will be ready for installation on ISS in early 2017.

3.5.3 GEO Task CL-02: Global Carbon Observation and Analysis (Antonio Bombelli, GEOCARBON Project Manager, CMCC)

GEO Task CL-02 envisages progress in the following areas:

- Providing improved information and products, outreach, carbon portal
- Coordinating global observation networks measuring C pools and fluxes (considering both CO_2 and CH_4) across different domains (atmosphere, ocean and land) by different approaches (ground/space based, airborne)
- Providing improved (resolution and accuracy) C-budgets at different scales
- Develop an integrated Carbon Cycle Data Assimilation System (CCDAS) ingesting data from multiple data sources at different scale
- Validate space-based GHG observations and consolidate data requirements for the next-generation GHG monitoring missions

By 2015, it is anticipated that progress will be made in the following areas:

- A Carbon portal will be established (linked to the GEO Portal and complying the GEOSS Data Sharing Principles) as a single access point to the global C-cycle data.
- Updates of global and regional annual carbon budgets (CO_2 and CH_4), with a continuously reduced uncertainty.
- Improved methodologies for measuring and analyzing C-cycle data: develop agreed standards, improve global CCDAS; calibrate and validate space based observations of GHG.
- Easily understandable and accessible information products, useful for decision makers and the general public
- Global carbon monitoring networks improved and coordinated, toward an optimal, sustained and operational Integrated Global Carbon Observation and Analysis System by 2020.

GEOCARBON is a European-funded project to develop a coordinated Global Carbon Observation and Analysis System, supporting GEO toward building a Global Earth Observation System of Systems (GEOSS) for carbon during the last 3 years of the GEO WP (through 2015).

Upcoming events for GEOCARBON include the GEO Conference, “Towards a global Carbon Observing and Analysis System: Progresses and Challenges”, to be held in Geneva, 1-2 October 2013, which a focus on tropical C-budget and hotspots, observations from space in situ observations, the global CH4 cycle, model data fusion at global and regional scale, and Carbon and policy. The next GEO CL-02 Task meeting will take place immediately following the GEO conference in Geneva on 3-4 October 2013, with the goals of revamping the work of the CL-02 task, consolidating and enlarging the GEO community contributing to the “carbon” task, improving global coordination, ensuring commitment, planning next activities, and establishing the new GEO Carbon Community of Practice.

3.5.4 Discussion: Towards a GHG Satellite Constellation? (All; Claus Zehner, lead)

Discussion topics included:

- Is a CEOS GHG Satellite Constellation needed?
- Could such a Constellation help to get funding for scientific projects and future GHG missions?
- Interaction with other ongoing international activities (e.g., GEO Task CL02)
- Definition of activities (short term, long term – e.g., sponsoring of International Workshops on Greenhouse Gas Measurements from Space activities, algorithm intercomparison, generation of common products)
- Writing of a brief (10-20 pages) White Paper to define these activities

Meeting attendees decided that it would be beneficial (especially to support future planned GHG satellite missions) to follow the example of the ACC Air Quality Constellation to write a white paper on a similar Constellation for GHG missions with an emphasis on algorithm improvements and uncertainty quantification. A formal timeframe for this activity will be agreed in the near future.

3.6 Other Issues

3.6.1 Ongoing CEOS Activities Relevant to the Atmospheric Composition Constellation (Richard Eckman, ACC Co-Lead, NASA)

Outcomes of the recent CEOS SIT-28 meeting, held in Hampton, Virginia, from 11-14 March 2013, were discussed. It was noted that current ACC projects respond directly to multiple CEOS priorities, including Climate Monitoring and Research (ECV generation, AQ Constellation), Carbon Observations (GHG Constellation), and Disaster Risk Management (Volcanic aerosol monitoring). ACC was asked by SIT to compose an updated constellation Terms of Reference document using the newly agreed template, to provide an example to other virtual constellations.

Atmospheric Composition Constellation Meeting (ACC-9) - 18-19 April 2013, EUMETSAT Agenda

April 18	ACC Workshop on the possible combination of long term total ozone column (TOC) data sets derived from ESA, EUMETSAT, NASA, and NOAA Missions	
08.30 – 08.50	Registration	
08.50 – 09.05	Opening	A. Ratier – EUMETSAT DG
09.05 – 09.10	Scope of the Workshop	C. Zehner - ESA
09.10 – 09.20	Total Ozone Validation Database/Protocol (satellite data sets included, format, list of ground-stations, validation data used, O3 spectroscopy used)	JC. Lambert - BIRA/IASB
09.20 – 09.35	ACSO Activities and latest results on combined TIR/UV Ozone Retrievals	J. Orphal - KIT
09.35 – 09.50	Latest O3 Spectroscopy Measurement Results	M. Weber - University Bremen
09.50 – 10.10	Key features of the latest O3_cci Total Ozone Algorithm	M. Van Roozendael - BIRA/IASB
10.10 – 10.30	Chinese Missions for polar ozone depletion monitoring	F. Huang – CMA
10.30 – 11.00	Coffee Break	
11.00 – 11.20	Instrumental differences found/solved in European data sets	D. Loyola - DLR
11.20 - 11.40	USA/European TOC Brewer Intercomparison	JC. Lambert – BIRA/IASB
11.40 – 12.00	USA/European TOC Dobson Intercomparison	ML. Koukouli - AUTH
12.00 – 12.20	USA/European TOC SAOZ Intercomparison	JP. Pommereau - LATMOS
12.20 – 14.00	Lunch Break	
14.00 – 14.20	Key features of the latest SBUV Total Ozone Algorithm	R. McPeters - NASA
14.20 – 14.40	Key features of the latest TOMS Total Ozone Algorithm	D. Haffner - NASA
14.40 – 15.00	Instrumental differences found/solved in USA data sets	R. McPeters - NASA
15.00 – 15.20	USA/European TOC Zonal Mean Intercomparisons	G. Labow - NASA
15.20 – 16.00	Coffee Break	
16.00 – 16.20	Using data assimilation to combine USA/European TOC data sets?	R. van der A - KNMI
16.20 – 16.40	An approach to combine USA/European TOC data sets	D. Loyola – DLR
16.40 – 17.20	Discussion on the possibility to generate a combined USA/European TOC ECV	all
17.20 – 17.30	Define date and place for a follow up workshop on including other data sets	all
17.30 – 17.45	From IASI to IASI-NG: what to expect for ozone	C. Clerbaux- CNRS&CNES
18.00 – 20.00	Social Event at EUMETSAT	
	Discussion	all

April 19	ACC-9 Meeting	
09.00 - 09.20	ESA Activities on Volcanic Ash	C. Zehner - ESA
09.20 – 09.40	EUMETSAT Activities on Volcanic Ash	R. Munro - EUMETSAT
09.40 – 10.00	NASA Activities on Volcanic Ash	N. Krotkov - NASA
10.00 – 10.20	The ACC Air Quality Constellation	J. Al-Saadi - NASA
10.20 – 10.40	Coffee Break	
10.40 – 11.00	TEMPO status	K. Chance - SAO
11.00 - 11.20	Sentinel 4 status	B. Veihelman - ESA
11.20 – 11.40	GEMS status	J. Kim – Yonsei University
11.40 – 12.00	Sentinel 5P status	P. Veefkind - KNMI
12.00 – 12.20	Results of the 2012 OSSE Workshop at ECMWF	D. Edwards - NCAR
12.20 – 13.30	Lunch Break	
13.30 – 13.50	Air Quality Meta Data and the GEO AQ CoP	M. Schultz - FZ-Juelich
13.50 – 14.10	First steps toward AQ constellation cal/val: pre-launch instrument characterisation activities	J. Al-Saadi for S. Janz – NASA
14.10 – 15.00	Discussion on the Air Quality Constellation	
15.00 – 15.30	Coffee Break	
15.30 – 15.50	GHG ECV generation activities at ESA	C. Zehner - ESA
16.00 – 16.20	GHG ECV generation activities at NASA/NOAA	A. Eldering - NASA
16.20 – 16.40	GEO TASK CL-02 – Global Carbon Observation and Analysis	A. Bombelli - CMCC
16.40 – 17.20	Discussion on a possible GHG ACC constellation (with links to GEO TASK CL-02, CEOS GHG Task Force, and International Workshops on Greenhouse Gas Measurements from Space activities)	all
17.20 – 17.30	Outcome of last CEOS SIT meeting - Date and place for next ACC meeting	R. Eckman - NASA

CEOS ACC-9 Participants
EUMETSAT, 18-19 April 2013

NAME	Institute
R. Koopman, B. Veihelman, C. Zehner, B. Bojkov	ESA
A. Ratier, R. Munro, M. König, T. Hewison	EUMETSAT
J. Orphal	KIT
M. Weber , H. Boevensmann	University Bremen
R. McPeters, D. Haffner, G. Labow, R. Eckman, M. DeLand, J. Al-Saadi, A. Eldering	NASA – only Al-Saadi in person (all others via WebEx)
L. Flynn	NOAA (by WebEx)
D. Edwards	NCAR
M. Van Roozendael, JC. Lambert	BIRA/IASB
F. Huang	CMA
D. Loyola	DLR
ML. Koukouli, D. Balis	AUTH
JP. Pommereau, C. Clerbaux	LATMOS
R. van der A, P. Veefkind	KNMI
K. Chance	SAO
J. Kim	Yonsei University
M. Schultz	FZ-Juelich
A. Bombelli	CMCC
J. Tamminen	FMI
C. Poulsen	RAL