WMO/IOC/UNEP/ICSU
GLOBAL CLIMATE OBSERVING SYSTEM (GCOS)

Doc. 4.4
(14.II.2011)

3rd GRUAN Implementation-Coordination Meeting (ICM-3)
Queenstown, New Zealand
28 February – 4 March 2011

Session 4

Task Team 5 (Ancillary measures) progress report 01/2011

(Submitted by Thierry Leblanc and Tony Reale)

Summary and Purpose of Document

Progress report from the task team 5 (Ancillary measures) covering first period till 01/2011.

February 2011 Extended Report of the GRUAN Task Team on Ancillary Measurements (“Task Team 5”or “TTAM”)

Recent Interface with other expert teams

May 2010: Water Vapor Raman Lidar Calibration Workshop (NDACC)

A workshop on the calibration of water vapor Raman lidars (hosted by D. Whiteman, NASA/GSFC) gathered 30+ lidar experts from the NDACC community and beyond. The accuracy requirements for long-term trend monitoring, satellite validation and mesoscale meteorology were estimated. For trend monitoring, less than 50% total random (i.e., unbiased) uncertainty in the UT for a single profile is needed. For satellite validation, profile accuracy better than 15% is needed throughout the troposphere, and for mesoscale meteorology (process studies) uncertainty of 10% in the lower to mid troposphere is needed. The accuracy of the various lidar calibration methods was then reviewed and assessed. No method proved to be unarguably more accurate than any others. The so-called “radiosonde method”, which consists of a “one-point” (more generally, best fit) normalization of the lidar profile to a radiosonde measurement in the lower troposphere, is conceptually the most straightforward of all methods. The calibration accuracy in this case depends largely on that of the radiosonde itself, as well as the quality of the spatio-temporal match between the lidar and radiosonde profiles. Overall it was estimated to range between 5% and 15%. Simultaneous and co-located radiosonde launches are highly recommended for optimum use as a lidar calibration source. The so-called “Total Column method” uses the Total Precipitable Water (TPW) measurements of co-located GPS. The lidar profile is analyzed such that the TPW of the lidar profile closely matches that of the GPS measurements. As with the radiosonde method, its accuracy depends on that of the GPS itself. It also depends on the lowest altitude sounded by the lidar, which is usually not the ground. Because of this limitation in the lidar, accurate ground measurement of water vapor mixing ratio is useful. As for the radiosonde method, its accuracy depends on that of the GPS itself. It also depends on the lowest altitude sounded by the lidar, which is usually not the ground. The spatio-temporal match is less critical since the bulk of the TPW resides in the lowermost troposphere, i.e., where the columns sounded by the GPS and lidar are least distant from each other. An alternate measurement source of TPW to GPS may be used, namely microwave or FTS. The most recent comparisons have shown agreement of different GPS TPW measurements of approximately 10%. The last method discussed at the workshop is the so-called “absolute” or “experimental” method. It is conceptually the most adequate, but in practice the most difficult to perform. It consists of determining the efficiency ratio of all components of the instrument through which the analyzed signals propagate. That includes transmittance of the telescope(s), transmittance of all optical filters and splitters, photomultiplier efficiencies, and quantum efficiencies of all relevant channels of the counting system. It is labor intensive, therefore almost impossible to achieve on a daily basis, though recent attempts were successfully made under 30 min. The estimated accuracy using this method ranges from 7% to 20%. Finally the “hybrid” method was proposed to be used within the NDACC community to insure the proper long-term monitoring of the lidar calibration. This method is not a calibration method per-se, but uses a calibrated laboratory lamp to monitor the stability of the lidar receiver total transmission between two calibration campaigns. Calibration campaigns could be performed for example at one-year intervals. If the lamp ratio does not vary, or slowly varies between these campaigns, then no calibration is required between the campaigns, thus reducing cost (typically by launching radiosondes only during campaigns, not on a routine basis).

Workshop notes can be downloaded from:
http://ndacclidar.posterous.com/#!/ndacc-calibration-workshop-notes-0

December 2010: ISSI International Team on NDACC lidar algorithms

A team of international experts was recently formed (leader: T. Leblanc, NASA/JPL) to work on the standardized reporting of vertical resolution and uncertainty in the ozone and temperature lidar data archived at the NDACC data handling center (located at NOAA and mirrored at NILU). NDACC lidar PIs are required to use the same standard file format (Ames 2110), but the actual content of the data and metadata remained inhomogeneous from one file to another. Different definitions of vertical resolution and different uncertainty estimation schemes result in discrepancies between the various NDACC lidar datasets. The objective of the ISSI Team is to standardize these definitions without imposing the use of a specific resolution and uncertainty scheme to the individual PIs. The first meeting was held in December 2010. At this meeting, the various methods of calculating and reporting vertical resolution (data filtering) were reviewed. Simulation and testing tools are currently being developed to compare the effect of these filtering schemes. The tests will be performed this spring on the actual lidar analysis algorithms. The definition and propagation of uncertainties were also reviewed at the first meeting, and will be standardized in a similar manner. The project is expected to end by early 2012. A similar project is planned for the aerosol and water vapor lidar algorithms (2012+).

Meeting #1 Summary Notes can be downloaded from: http://www.issibern.ch/teams/ndacc/

November 2010: MWRNet synergies

A special working group meeting of the Microwave Radiometer Network, MWRNet, has been held right after the EG-CLIMET WG/MC meeting in Cologne, 16-18 November 2010. The aim is to register existing tropospheric microwave profilers (temperature and humidity up to 5 km) and to exchange knowledge, set standards and harmonize data analysis in order to achieve a consistent network.

Inventory of registered instruments and contacts: http://cetemps.aquila.infn.it/mwrnet/.

December 2010: NDACC-EARLINET and TTAM-GATNDOR synergies

T. Leblanc recently met with R. Hoff (EARLINET co-chair) to discuss future plans for the harmonization of water vapor and aerosol data template in the NDACC and EARLINET data files. This work is still ongoing. An operational template already exists for EARLINET aerosols. An experimental template exists for NDACC aerosols based on the EARLINET template. A preliminary template exists for NDACC water vapor. Also, T. Leblanc briefly met with F. Madonna to discuss areas of collaboration between TTAM and GATNDOR and avoid unnecessary overlap of activities. These discussions will continue at the ICM-3.

EARLINET website: http://www.earlinet.org/

Ongoing: Joint Polar Satellite System (JPSS)

Coordination with cal/val teams for the NOAA Joint Polar Satellite System (JPSS) concerning synergy between sensor data record (SDR) and environmental data record (EDR) calibration and validation activities focused at GRUAN sites are oursued. A variety of routine and special activities in coordination with upcoming NOAA Preparatory Project (NPP) launch of advanced microwave (ATMS) and FTIR (CrIs) instrumentation onboard the C1 satellite (October 2011) are planned. Opportunities to coordinate and/or expand these activities to include interactions and routine cross validation at GRUAN sites are under consideration and will be elaborated upon at IOC-3 (POC: A. Reale and C. Barnett of NOAA Center for Satellite Applications and Research (STAR).

Update on the Inventory of potential instruments

Lidars

Non-exhaustive list of systems with a “long-term” monitoring component in their program. Reaching 15-20 km (with several hours integration time): Table Mountain Facility (Leblanc, JPL) and Purple Crow Lidar (Sica, UWO). Reaching 10-15 km (with several hours integration time): Mauna Loa Observatory (Barnes, NOAA), Observatoire de Haute-Provence (Keckhut, CNRS), Rome-Tor-Vergata (Congedutti, CNR), Payerne (Haefele, Meteoswiss), and ARM-SGP (Newsom, DOE). Other systems, with a maximum altitude range yet to be confirmed: Potenza (Pappalardo, CNR), Lindenberg (Reichardt, DWD), Cabaw (Apituley, RIVM), Greenland (Neely, NOAA), Beltsville (Demoz, HU), Eureka (Strawbridge, EC). Mobile systems (varying degree of performance depending on campaigns): ALVICE (Whiteman, GSFC), STROZ (McGee, GSFC), AT (McGee, GSFC), MARL (Schrems, AWI) and ComCAL (Schrems, AWI). There are other water vapor Raman lidar instruments, mostly dedicated to the study of the lower troposphere (pollution, boundary layer). Finally, two new instruments, with a performance expected to exceed that of any existing instrument, are now under construction: Zugspitze (Trickl, IFK), and Reunion Island (Baray, LaCy).

Microwave

For an inventory of tropospheric microwave profilers check the MWRNet webpage mentioned above. Microwave radiometers for stratospheric and mesospheric water vapor (30 – 80 km): Bern, Switzerland (Kämpfer, Univ. of Berne, NDACC); Seoul, South Korea (Kämpfer, Univ. of Berne); Mobile instrument (Kämpfer, Univ. of Berne); Mauna Loa Observatory (Nedoluha, NRL, NDACC); Table Mountain Facility (Nedoluha, NRL, NDACC); Lauder (Nedoluha, NRL, NDACC); Onsala, Sweden (Forkman, Chalmers University of Technology, NDACC); Andoya, Norway and Kühlungsborn, Germany (Hartogh, MPI-Lindau); Karlsruhe (Hochschild, KIT).

FTIR

There are two global networks of high-quality ground-based FTIR system: NDACC (Network for the Detection of Atmospheric Composition Change, www.acd.ucar.edu/irwg/) and TCCON (Total Carbon Column Observing Network, www.tccon.caltech.edu/). For NDACC high resolution solar absorption middle infrared spectra are recorded at about 20 sites often since 15 years and more. TCCON is in operation since a few years only, However, the number of sites is steadily increasing (currently there are about 15 operative TCCON sites). The table in Annex-1 below lists 44 sites that are either in the TCCON or IRWG networks, possibly both and several sites that are currently affiliated and are prospective contributing sites.

Satellite and Assimilations

From T. Reale: Polar satellites including weather monitoring instrumentation (IR, FTIR, MW, RO):

- JPSS: CrIs, ATMS, VIIRS, afternoon (October 2011)
- MetOp: HIRS, AVHRR, IASI, AMSU, MHS late Morning
- NOAA-18, 19: HIRS, AVHRR, AMSU, MHS afternoon
- DMSP (F-16,17): SSMIS. Early morning
- EOS Aqua: AIRS afternoon
- COSMIC RO

From M. Schröder: Relevant satellite instruments, retrievals and products (water vapor) are covered in a paper ("Satellite remote sensing of water vapor: An Overview") which we will submit to Remote Sensing very soon.. The draft is available for distribution after M. Schröder receives and evaluates the reviews.

Update on the data products, including uncertainty budgets

Lidar

NDACC lidar data products are available for ozone, temperature, and aerosols at the NDACC Data Handling Facility (DHF). Some data are publicly available immediately upon archive while other data are public between one and two years after their initial archive. There is not yet an official lidar water vapor product at the NDACC DHF. These data are available upon request to the PIs. This is expected to change in 2011 with the finalization of the NDACC water vapor data format. For non-NDACC systems, data availability depends on the site considered, and therefore requests should be made accordingly to the PI directly. Uncertainty budgets for NDACC ozone and temperature lidar products are being standardized (see above paragraph on ISSI Team). For water vapor lidar, uncertainty budgets were, so far, specifically focused on calibration (see above paragraph on Calibration Workshop). Standardization similar to that in progress for ozone and temperature is planned for 2012.

Microwave

For tropospheric profilers there is not yet a common data format and data are not yet available on a central archive. Efforts in this direction are being done in the frame of MWRNet. NDACC data products are available for water vapor, ozone, and other species at the NDACC Data Handling Facility (DHF). With very few exceptions an optimal estimation (OE) algorithm is used to invert the radiometer data. OE allows a good characterization and definition of the uncertainty and vertical resolution, respectively. Typically, uncertainty of stratospheric/mesospheric water vapor profiles is around 5 to 10 % and the vertical resolution is around 10 to 15 km. Uncertainty budgets of middle atmospheric water vapor radiometry are assessed in the frame of a science team (team lead N. Kämpfer) by ISSI (International space science institute).

For details consult webpage: http://www.iapmw.unibe.ch/research/projects/issi/index.htm

FTIR

One FTIR measurement takes only a few minutes. Spectra from both networks (NDACC+TCCON) allow the retrieval of very precise total column amounts (precision of 1-2%). In addition tropospheric profiles with a modest vertical resolution and a precision of about 5-10% can be retrieved. The vertical resolution ranges from 3 km in the lower troposphere to about 10 km in the upper troposphere, whereby the very high resolution of the NDACC spectra provide better upper tropospheric sensitivity than the high resolution TCCON spectra. In the framework of the project MUSICA (MUlti platform remote Sensing of Isotopologues for investigating the Cycle of Atmospheric water, www.imk-asf.kit.edu\musica, led by M. Schneider) profiles will be retrieved for 10 selected NDACC sites but there is currently no similar TCCON water vapour profile retrieval initiative. There is not yet an official FTIR water vapour product at the NDACC DHF. These data are available upon request to the PIs. During 2011 and 2012 an H2O and HDO/H2O database for the 10 NDACC MUSICA sites will be created. The water vapor profile data products are maturing quickly. It is probable that in the IRWG that water vapor becomes a standard product including isotopic amounts.

Satellite and assimilations

Temperature (surface to 0.01 hpa), H_20 Vapor (srfc to 200 hPa), Cloud Fraction, Top (P, T) , O_3, CO_2, Surface T, Emissivity, Cloud Liquid water, TPW, LW. Strategies for validation and error estimation typically are project oriented with a push at NOAA STAR for centralized standard validation protocols.

Within the ESA DUE GlobVapour (www.globvapour.info) and the ESA STSE WACMOS (www.wacmos.org) projects three new water vapour products were generated: total column water vapour from combined SSM/I and MERIS observations and from merged SEVIRI and MERIS observations making use of the complementary information over ocean (SSM/I) and land (MERIS) as well as of the high temporal and spatial resolutions of SEVIRI and MERIS, respectively; layer integrated water vapour from merged SEVIRI and IASI observations.

Update on Instrument calibration

Lidar

See Calibration Workshop notes above

Microwave

The calibration of tropospheric profilers is critical and requires absolute calibration with an external reference (liquid nitrogen load) in regular intervals. The value of the sky tip measurements to calibrate the water vapor channels is under discussion and external calibration might be favored. In this respect, standards will be defined in the frame of MWRNet. In the frame of NDACC recommendations for retrieval parameters (spectroscopy, a priori…) are given for instruments measuring stratospheric/mesospheric water vapor. Furthermore, recently developed mobile systems allow straight forward inter-comparisons. This has been successfully demonstrated in the measurement campaigns at Table Mountain (MOHAVE), on Zugspitze, Germany and in Sodankylä, Finland during the LAP-

BIAT campaign early 2010. Big efforts are being done to extend the altitude range towards the lower stratosphere and the lower limit is actually at ~24 km. This allows for an overlap with balloon soundings and gives to opportunity to perform inter-comparisons with in-situ hygrometers.

FTIR

The technique is self-calibrating (differential absorption principle). A constant high instrumental performance is achieved by regular low-pressure gas cell measurements (these measurements are in particular important when aiming on stratospheric absorbers). Retrievals employ published line parameters that are based on laboratory measurements. These have large effects and can be have precisions of 5-20%. Updates are intermittent but continue. It is likely that a closer review of these parameters will be in order in the not too distant future in a manner similar to what has been done with O3.

Satellite

STAR Integrated calibration/Validation System (HIRS, Microwave) including SNO
http://www.star.nesdis.noaa.gov/smcd/spb/calibration/icvs/index.html/.

Update on Validation strategies and results

Lidar

It is well established that most existing water vapor lidars require thorough validation before they can be considered fully reliable for GRUAN-like measurement activities. The use of multiple radiosondes and multiple Frost-Point hygrometers is mandatory. Multiple simultaneous and co-located techniques, including balloon-borne in-situ and ground-based remote sensing, are recommended. The logistics and operation of the recent MOHAVE-2009 campaign held at the JPL-Table Mountain Facility could be used as a reference to set standard guidelines for “GRUAN-certified” validation campaigns.

Microwave

No specific activity to report.

FTIR

In case there are new spectroscopic parameters (e.g. update of the HITRAN parameters) a validation to coincident radiosonde profile measurements is recommended. So far FTIR water vapour total column amounts have been compared to other techniques at Izaña, Ny Ålesund, Zugspitze, Jungfraujoch, and Table Mountain Facility. Tropospheric FTIR water vapour profiles have been compared to other water vapour profiling techniques at Table Mountain Facility (MOHAVE-2009) and are regularly compared to Vaisala radiosondes at Izaña (for NDACC and TCCON retrievals). On going regular coincident measurements with the approximately bi-weekly NOAA FPH are being made At NCAR in Boulder. Though not an official NDACC site these data are of NDACC quality. These serve to validate the retrieval process wrt the FPH standard.

Satellite and Assimilations

From T. Reale: STAR Integrated calibration/Validation System (HIRS, Mwave) including SNO at http://www.star.nesdis.noaa.gov/smcd/spb/calibration/icvs/index.html. Global Space Based Inter-Calibration System (GSICS): international collaboration (WMO, CGMS, NOAA …) to monitor and standardize data from operational weather and environmental satellites of the Global Observing System. NWP SAF (EUMETSAT, UKMO, KNMI, MeteoFrance, ECMWF) routinely monitor instrument performance (bias, SD) based on differences from NWP calculated radiance.
From M. Schröder: The merged SEVIRI+IASI product has a temporal resolution of 3 hours and utilises the high vertical resolution IASI and the high spatial resolution SEVIRI observations. At present the added value of the merged product is anlysed by comparison to high temporal resolution ground-based MWR observations from MOL by closely analysing the products quality in temporal vicinity to IASI overpasses. At CM SAF a prototype bias monitoring has been developed and implemented. An interim version utilised radiosonde and other standard ground-based observations from MOL and radiative transfer to determine the bias between RT and SEVIRI observations. The monitoring has been extended to utilisation of ground-based Lidar observations from MOL. The Lidar data contain water vapour information only. Therefore, temperature observations from radiosondes are used which the disadvantage of reduced temporal sampling.

It is foreseen to transfer offline ATOVS atmospheric profiles (water vapour and temperature) from CM SAF to NOAA STAR for implementation in its NPROVS.

Update on Meta-data

Lidar

No specific activity to report.

Microwave

No specific activity to report.

FTIR

FTIR data archived at the NDACC DHF are now GEOMS compliant HDF files, we might expect this to be a standard conveyance of FTIR water vapor data products for GRUAN. Meta-data included in this file are available on request.

Satellite

No specific activity to report.

Update on the Definition of Best Measurement Practices

Lidar

No specific activity to report.

Microwave

No specific activity to report.

FTIR

NDACC/IRWG guidelines for observations and retrievals for member groups can be found there: http://www.acd.ucar.edu/irwg/irwg_info.html/

Satellite

No specific activity to report.

Update on the Routine Collection and Display of Data

Respective data product programs at STAR facilitate respective data collection and display of sensor data records (SDR) and derived environmental data records (EDR). NPROVS provides NOAA STAR with a centralized validation protocol for the routine, integrated, monitoring and inter-comparison of EDR's composed of derived atmospheric weather products from polar orbiting and GOES environmental satellites. This is primarily achieved through the compilation and analysis of collocated radiosonde, NWP and independently processed satellite product systems; currently 19 operational and experimental products systems are included. NPROVS compiles collocations on a daily basis with all collocations routinely archived at STAR. NPROVS includes a variety of analytical interface and sampling options (EDGE) including satellite and Raob QC, space and time windows, terrain designation, individual and common denominator sampling, radiosonde instrument type selection, regional (i.e. GOE Conus) designation and more. Analysis on real-time weather (daily, weekly) and climate scales (monthly, seasonal, annual) are facilitated. Plans for expanded access and validation against GCOS Reference Upper Air Network (GRUAN) reference radiosonde and selected ground observations are outlined.

Update on Guidelines on Practices and Protocols for Site and Measurement Certification

Lidar

No specific activity to report.

Microwave

No specific activity to report.

FTIR

No specific activity to report.

Satellite

No specific activity to report.

Update on GRUAN-TTAM members interaction

There has been no meeting yet of all GRUAN-TTAM members together. A few members met at various occasions. These small, informal, meetings led to no significant action besides general programmatic information between the team members. There has been no GRUAN-TTAM teleconference meeting. Team-wide communication has been limited to email only, and was mainly focused on the preparation of the present report.

Update on GRUAN TTAM Membership

There has been no progress in this area. Finding non-US and non-EU collaborators with adequate availability and/or expertise remains a difficult process. Action is still ongoing. As of February 2011, the current Team composition is as follows:

- Thierry Leblanc (NASA/JPL), co-chair
- Tony Reale (NOAA/NESDIS), co-chair
- Alexander Haefele (Meteoswiss-Payerne): Microwave, Lidar, GRUAN-Payerne
- Nik Kämpfer (Univ. Bern): Microwave
- Jim Hannigan (NCAR): FTIR
- Matthias Schneider (KIT/IMK-ASF and AEMET): FTIR
- Marc Schroder, (DWD): Satellite/data processing
- Michael Sommer (DWD): Satellite/data processing
- Dave Whiteman (NASA/GSFC): Lidar

Annex 1: List of FTIR instruments (see paragraph on potential sites)

Station	***N. Lat***	***E. Long.***	***MASL***	***Designation****
Eureka	80.05	273.58	610	3
Ny_Alesund	78.90	11.90	20	3
Thule	76.53	291.26	225	1

Station	***N. Lat***	***E. Long.***	***MASL***	***Designation****
Kiruna	67.84	20.41	420	1
Sodankyla	67.00	27.00	180	2
Poker_Flat	65.12	212.57	610	1
Harestua	60.20	10.80	596	1
St_Petersburg	59.88	29.83	20	4
Yekaterinburg	57.04	59.55	300	4
Tomsk	56.98	85.05	106	4
Bialystok	53.23	23.03	183	2
Bremen	53.10	8.90	27	2
Bratts_Lake	50.20	-104.20	587	4
Karlsruhe	49.09	8.43	110	2
Paris	48.97	2.37	60	4
Orleans	47.97	2.11	132	2
Garmisch	47.48	11.06	745	3
Zugspitze	47.42	10.98	2964	1
Jungfraujoch	46.55	7.98	3580	1
Park_Falls	45.95	269.73	442	2
Moshiri	44.40	142.30	200	1
Egbert	44.22	280.23	251	4
Rikubetsu	43.50	143.80	200	1
Toronto	43.66	280.60	174	1
Boulder	40.04	254.76	1612	4
Barcroft	37.58	241.76	3793	1
Lamont	36.60	262.51	320	2
Tsukuba	36.05	140.12	31	2
Table_Mtn	34.40	242.30	2300	4
Kitt_Peak	31.96	248.41	2060	1
Izana	28.30	343.52	2370	3
Mauna_Loa	19.54	204.43	3396	1
Mexico_City_UNAM	19.33	-99.18	2260	4
Altzomoni	19.12	-98.65	4010	4
Addis_Ababa	8.98	38.80	2444	1
Paramaribo	5.81	304.79	7	1
Ascension	-7.92	-14.33	10	2
Darwin	-12.42	130.89	20	2
Reunion_Maido	-21.07	55.38	2160	3
Reunion_St_Denis	-20.90	55.48	50	3
Wollongong	-34.41	150.88	30	3
Lauder	-45.05	169.67	370	3
Syowa_Station	-69.00	39.59	10	1
Arrival_Heights	-78.83	166.66	200	3

* Designations: 1=IRWG, 2=TCCON, 3=Both, 4=Other