EG-CLIMET Sub Working Group (SWG) meeting on
Microwave Radiometer Network: From Raw Data to Meteorological Products

Rationale:

The goal of this SWG meeting is to discuss and propose recommendations on best practice procedures regarding the homogenization of MWR operations that should in future be implemented within the International Microwave Radiometer network (MWRnet).

Agenda:

1. **Measurement modes**
    a. Feasibility of continuous data flows/ingestion
    b. Discussion on regular measurement modes

2. **Common calibration and/or calibration control procedures**
    a. different calibration procedures
    b. uniform standard methods for calibration monitoring and adjustment

3. **Common quality control**
    a. Useful quality controls
    b. common vs. instrument specific
    c. quality flags

4. **Common retrieval algorithms (conversion tools)**
    a. Standard retrieval algorithms
    b. Error characterization

5. **Metadata & data formats**
    a. Uniform naming and data formats
    b. Data flow and storing (central vs. distributed server)
    c. User needs (Climate, NWP, Telecom applications)

6. **Towards the establishment of the MWRnet**
    a. Automation of above points (1-5)
    b. Funding opportunities
    c. Ideas for the future

7. **Summary and recommendations**
    a. Recommendations
    b. Actions

List of attendees:

1. CIMINI Domenico (CD) MC-substitute member
2. CZEKALA Harald (CH) MC-substitute member
3. DUPONT Jean-Charles (DJC) WG member
4. GAFFARD Catherine (GC) MC member
5. GUELDNER Juergen (GJ) WG member
6. HAEFELE Alexander (HA) MC-substitute member
7. LOHNERT Ulrich (LU) MC member
8. MAIER Olaf (MO) WG member
9. NASH John (NJ) MC member
10. PERLER Donat (PD) WG member

Remotely

11. MADONNA Fabio (MF) WG member

Report:

1. Measurement modes

For Measurement modes is intended the instrument duty cycle and all the procedures to optimise the observations with respect to the applications.

a. Feasibility of continuous data flows/ingestion

The feasibility of continuous data flow and ingestion is discussed since it is at the basis of an observation network that aims to be used in near real time (NRT) applications, such as nowcasting and numerical weather prediction (NWP). GUELDNER Juergen (GJ) reported the DWD experience during the LUAMI campaign, in which MWR data from 8 radiometers were collected and compared to NWP model output and GPS-IWV for a period of 4 weeks. The data flow was based on daily data file transfer and it demonstrated to be regular and with no interruptions.

Most of the MWR operated by the attendees provide data that can be accessed continuously by remote access, as confirmed by GJ, LOHNERT Ulrich (LU), HAEFELE Alexander (HA), MAIER Olaf (MO), DUPONT Jean-Charles (DJC), MADONNA Fabio (MF).

GAFFARD Catherine (CG) and NASH John (NJ) say that of the 3 MWR currently operated by MetOffice in the FUND campaign, 1 is accessible remotely (netCDF files are produced with Owan Cox's routine). The 2nd one is not yet connected to the network and the 3rd one is connected but does not work, as it needs some software upgrade but because of a lack of resource no one had the time to discuss with the manufacturer to get this upgrade. PERLER Donat (PD) says that their MWR is currently not operational.

b. Discussion on regular measurement modes

Each MWR can operate with different modes, including zenith viewing, elevation scan, azimuth scan, calibration target observations and with different integration times. This discussion aims at concurring on measurement modes that are suited for certain applications, mainly NWP and climate. Indeed, these two applications have different characteristics and requirements, and therefore will probably lead to different recommendations. The most important is probably that frequent scanning is more suited for NWP, while continuous zenith viewing for climate benchmarking.

We started with a survey of measurement modes adopted currently.

UL: the MWR operating at JOYCE applies the following duty cycle: 1-side elevation of a total of 3 min, followed by 7 min zenith viewing, followed by azimuth scans at 5deg resolution and alternating between 30 and 45 deg elevation.
HA/MO: the MWR operated by MeteoSwisse use the measurement mode suggested by the manufacturer (RPG). Calibration: Tipping curves (one side) every 10min for the calibration of the WV channels, relative calibration every 5min and absolute calibration every 30min. Measurements: Boundary layer scans (one side) every 20min (Tint=100s), the rest is zenith looking. No azimuth scan.
GJ: the MWR operated by DWD apply the following duty cycle: 1 zenith viewing; 1 viewing at 15 degrees elevation (equivalent to roughly 3 air masses).
GC: for the FUND campaign, the MetOffice is testing 3 MWR. Two duty cycle set-ups were decided to optimise either temperature or humidity profiling. The duty cycle dedicated to humidity profiling is: continous zenith view 1s for brightness temperature (60s integration time,for humidity and temperature profiling), noise diode calibration every 2h ; black body (BB) calibration (every 5 min, 4 s integration time); 1-side elevation scan (3 min) every hour. The duty cycle dedicated to temperature profiling is: zenith view as before: 1s integration time for TB, 20s integration time for zenith temperature profile and 200s for humidity1 side elevation every 5 minutes, integration time 100 s; black body (BB) noise calibration and tip curve like for the other mode. For the 2 set ups, four sky tip are attempted per day.
DJC: the MWR operated at SIRTA applies the following duty cycle: zenith view (10 min); black body (BB) calibration (1 min); 1-side elevation scan (10 min).

The discussion followed with these comments:
CH: For the retrieval of boundary layer (BL) temperature profiles, slower elevation scan is recommended for catching small BL variations. Note that brightness temperatures (Tb) at all channels are measured at any elevation angle viewing. The minimum elevation angle is limited by the MWR beamwidth, which can cause contamination by the ground. Currently, half-power half-width beamwidths in the 55-60 GHz range for the most common commercial MWR are ~1.8° for RPG HATPRO (at 55 GHz) and ~4-5° for Radiometrics MP-3000 (specify frequency).
NJ: For NWP, the retrieval of BL temperature is of utmost importance. BL temperature profiles are probably the most important selling point of MWR. Therefore, elevation scanning is strongly required. It is important to understand how often temperature profiles are likely to be provided to users, which in turn depends on the atmospheric features that are intended to be monitored.
MF: It is really important to include in routine operations also scanning measurements both for increasing the accuracy of the retrieval of the temperature profile as well as for improving the accuracy of the retrieval of LWP.

2. Common calibration and/or calibration control procedures

Different types of MWR rely on different calibration procedures, based on internal loads, external targets, sky dip (also called tipping curve). The discussion here focuses on the design and development of standard methods for checking and correcting for calibration offset and/or drift.

a. different calibration procedures
The discussion starts with a presentation by GC/NJ on results from the recent MWR intercomparison experiment carried out at the UK MetOffice. Two identical radiometers were deployed side by side. GC/NJ noted systematic differences in Tb at 58 GHz of the order of 1-2 K. The absolute calibration of these channels should be better than 1 K, since Tb is close to

reference ambient temperature. GC/NJ point out that the conditions in UK disfavour frequent cryogenic calibration procedure. This for both meteorological conditions, technical difficulties, and site management issues (for example: high humidity leading to quick condensation over the MWR mirror, drizzle, personnel duty, etcetera…).
Significant Tb differences of 1 to 2 K are found at other channels in the 50-55 GHz range with a difference of ~6.5 K in the channel at 52.28.
Significant Tb differences can be of 1K(channel 25.44) and jump of 1 K are found at channels in the 22-25 GHz, in correspondence to calibration update derived from sky dip data.
Calibration coefficient updates seem to introduce step-like discontinuity in the Tb comparison.

The presentation stimulated the following discussions:

CH: The MWR units operated by MetOffice are HATPRO generation 1 (acquired 02/2007 and 03/2007, respectively) that are more than 3 years old in June 2010. These units have been inspected in summer 2008 (sent at the manufactor house in august 2008 return in october) and in February 2009, for Hatrpro1 and Hatpro2 respectively. Inspection every 1.5-2 years is recommended; inspections are done in manufacturer's house and cannot be done in the MWR operational place (the cost is about 2 keuro + transportation).
The 1-2 K bias between Tb at the two collocated 58 GHz channels may be explained by deterioration of the temperature sensor measuring physical temperature of the BB target. HATPRO generation 1 have just one target temperature sensor, while generation 2 have two sensors, providing a way to monitor sensor degradation.
The Tb differences at 55-56 GHz channels may be explained by shifts in the spectral response function. This may affect HATPRO generation 1, while for generation 2 hardware the spectral response function is well characterized end-to-end, from optics to digital output, and thus the equivalent monochromatic frequency is better understood and harmonized throughout different units.
Concerning the cryogenic calibration procedure, there are good practises that should be followed. In summary: (1) fill the target; (2) wait until boiling bubbles stop; (3) check for complete immersion of absorber tips; (4) place the box in the calibration position; (5) run the calibration; (6) check for condensation on the mirror plate and reject calibration if condensation had formed or tips are not covered at end of the two-minute calibration procedure. This procedure should avoid erroneous cryogenic calibration. The cryogenic calibration is recommended once every few months (usually 6 months), as receivers for the 55-60 GHz channels are stable over a period of about 6 months. Receivers for 20-30 GHz channels are believed to be stable for periods even longer than 6 months. Therefore, concerning the sky dip (or tipping curve) calibration method, CH doesn't see the need for frequent sky dip, especially since the damage done by slightly erroneous calibrations is worse than the drifts within half a year. This estimation is of course subject to the vendor specific hardware.
LU: The experience at UniKoln tells that the RPG radiometers are very stable. Cryogenic calibrations over 1 year did not show differences larger than 1 K. A good practise is to place the cryogenic target in place before performing the calibration and check the Tb values. If Tb are within 1 K from the expected value, a new cryogenic calibration would be not useful and can be avoided. Sky dip calibration have momentarily been completely removed by the operational duty cycle of JOYCE MWR.
Results from a re-processing effort performed using a 3-year data set collected at MeteoSwisse were shown. Observed minus radiosonde-simulated Tb comparison in clear sky showed discontinuities in correspondence to cryogenic calibration.
CD: For receivers that are not as stable as stated by CH, a long time series of calibration coefficients from periodic sky dip scanning may help monitoring drifts in 20-30 GHz channels.

GJ: Comparisons of observed radiances versus radiosonde-simulated TB can be generated automatically on demand at Lindenberg. For cloudy conditions the experience at DWD showed observed minus simulated biases at 50-55 GHz channels that are of the same order of the ones seen by LU/MO at Payerne and by GC in UK. For 12 cloudless cases during the period from 20 to 31 Oct 2010 the mean deviation of the operational MWP are usually less then or equal to1 K except for channels 7 and 8 (52.28 and 53.85 GHz) where the mean deviation is about twice as much.

b. uniform standard methods for calibration monitoring and adjustment

The calibration of MWR should be monitored to avoid uncalibrated data entering in the retrieval process and the following applications. Methods to monitor the calibration include the comparison of observed Tb with simulations from radiosonde (only in clear sky, since cloud liquid is not available), or comparison of retrievals with profiles radiosonde and/or NWP output. LU and MO showed the results from a re-processing effort performed using a 3-year data set collected at MeteoSwisse were shown. Observed minus radiosonde-simulated Tb comparison in clear sky showed discontinuities in correspondence to cryogenic calibration. Methods for mitigating these effects in the reprocessing stage were developed and tested. This method is well suited for re-processing of historical datasets and can be generalized to the MWRnet sites where collocated radiosonde are launched. The use of this method in an operational duty cycle requires quite frequent clear sky occurrences.
GJ at DWD developed automated procedures for checking daily the quality of MWR retrievals comparing with temperature, water vapour density and relative humidity profiles from radiosondes as well as the IWV with GPS-derived values.

3. Common quality control

Quality control procedures to check the quality of observed Tb and retrieved products are fundamental for providing the users with a mean for judging and eventually screen out data. There are quality control procedures developed by the MWR manufactures and running with the acquisition software as well as quality control procedures developed by operators based on their experience. The quality control procedure may be instrument specific and/or adaptable to other instruments.
CH explains briefly the quality control procedures adopted by RPG. A rain sensor detects the presence of rain, although screening data based on rain flag only may result in overkilling since some retrievals work unaffected by rain, e.g. the boundary layer T-profiling. Quality control of the observation information content during non-clear conditions is performed looking at the spectrum. For example, if the Tb spectrum reveals that the water vapour line at 22.2 GHz is “obscured” by the continuum emission from liquid water, then the quality of water vapour profiles is degraded accordingly from good to medium to low. The same apply for temperature profiles. This quality flag (high/medium/low) is variable-dependent; for example the quality of boundary layer temperature profiles stays medium even under light precipitation as slant observations and opaque channels are less affected by rain. The quality flags are encoded in the output file, i.e. level2 data (level0 is raw voltage, level1 is calibrated brightness temperature, level2 is retrieved data). Sanity checks are also performed to control the quality of observed Tb. Results from these sanity checks are encoded in the lv1 (house keeping) data (also a level1 data file type which is recorded alongside with the calibrated brightness temperature and other data).
MF remarks that the criteria for the data quality control should not make use of data from other ground-based remote sensing instruments. This will keep the quality control at reach of any MWR, regardless the level of infrastructure equipment.

a. Common vs. instrument specific

CD: A sanity/quality check on observed Tb could be implemented as resulting from a simulation- or measurement-based regression estimating Tb at one channel from the Tb at other channels. This sanity/quality control could be easily implemented for any MWR. Data quality flags adopted by ARM should be reviewed.
GJ: On Radiometrics systems, a rain sensor is present and rain flag is stored from lv1 to lv2 data. There may be other built-in quality/sanity checks, but no information is available. Additionally, DWD has developed its own quality checks taking into account the temporal variability of the radiances and the GPS IWV. This check is performed afterwards to separate out suspect values from the database which is used for the calculation of measurement-based regression operators operationally applied at Lindenberg.
NJ: Light precipitation is often present in UK, but this may not be a problem for the retrievals. Rain flags are necessary to screen out data, definitely for IWV/LWP, but not always for temperature profiles. A method should be developed to check the quality of retrievals during periods when the rain sensor detects precipitation.

b. Quality flags

Currently adopted quality control and sanity check procedures should be surveyed and prioritized. The results should be encoded in lv2 using an easy-to-interpret table.

4. Common retrieval algorithms

In order to convince NWP modellers and other users to employ MWR observations and retrievals there is need of a standardized retrieval algorithms that they clearly understand plus error characterization.
The discussion starts with a survey of the retrieval algorithms used operationally by the participants.
LU: Retrievals at JOYCE are currently performed using multi-linear regression techniques . Temperature retrievals are done using zenith and BL scan in combination. Relative humidity (RH) profiles are computed from retrieved temperature and water vapour density profiles every 15 minutes. The experience so far indicates better performances than direct RH retrieval.
CH: RPG offer retrieval algorithm based on linear/quadratic regression. For temperature retrievals, profiles from zenith viewing are obtained separately then those from BL scan. These data are stored in lv2 files. These two retrievals are combined in lv3 files, using a simple approach (spline fitting, which will be replaced by a direct level2 product in near future, requiring a dedicated retrieval). RPG offers direct RH retrieval. This seems to be more stable and well-constrained profile than indirect (through temperature and water vapour density) retrieval, since errors in temperature and water vapour density profiles combine such to give unrealistic RH profiles.
GJ: Retrievals at Lindenberg are obtained both with the original algorithm provided by the manufacturer (neural networks) and with a observation-based regression. The archived profiles of temperature, water vapour densitiy, and relative humidity are retrieved from zenith viewing.
DJC: Retrievals at SIRTA are obtained using the original algorithm provided by the manufacturer (linear regression).

The presentation by MetOffice generated the following reactions.
GC: The BL temperature retrieval seems to have the skills to detect the front passage. However, differences between radiosonde profiles and BL temperature retrievals are larger than ~1 K in the first 100 m, for colocated radiosonde launches in particular for Hatpro2, Hatpro1 is better. The difference between the 2 instruments are in agreement with the bias seen on the brightness

temperatures. Temperature profiling during rain seem to be acceptable. Therefore, good data may be flagged out by rain flag.
NJ: For temperature retrievals, 8-K inversion are well resolved, which is a good selling point for NWP. Retrieved relative humidity (RH) is not always consistent with cloud base infrared temperature (Tir) and/or liquid water path (LWP). An example in which despite Tir and LWP indicate cloud presence RH stay lower than 90% throughout the vertical range is shown. Although NWP users are probably interested in Tb and not in retrievals, these situations may undermine the NWP trust in MWR performances. The NWP requirement for RH is ~1%. This accuracy is unfeasible with MWR alone, but maybe it could be reached by synergetic retrieval.
LU/CH/CD: LWP and RH are not necessarily consistent, since they are retrieved by independent algorithms (though based on the same observed Tb). Conversely, variational approaches, as IPT and/or 1DVAR, would give consistent retrievals.
CH: Retrievals based on zenith viewing deteriorate more easily than those obtained from slant views.

a. Standard retrieval algorithms

CD proposes a one-dimensional variational (1DVAR) approach initialized with the output of a NWP model as a good candidate for a common retrieval algorithm. 1DVAR approach is well understood and accepted by the NWP community and it represents a first step towards the assimilation of MWR data into NWP models. Moreover, variational approaches provide a dynamic estimate of the retrieval error characteristics. 1DVAR approach could be easily implemented and generalized for any kind of MWR. Adopting a global analysis as the background, this is operationally available for virtually anywhere. However, the background and instrumental error covariance matrices are site and instrument dependent and need to be estimated for each operational site/MWR.
LU refer that the IPT is already used operationally at some MWR site. The current implementation requires that the cloud boundaries are know (from ceilometer/radar) and uses either a climatological mean or a radiosonde profile as background. IPT can be easily adapted to use a background from a NWP, by adopting the background error covariance matrix.
CD/LU: Variational approaches (such as 1DVAR/IPT) require a forward model operator. Few forward model operators were developed and are used by this community. However, to favour the NWP application it is recommended to develop a forward model operator that is already well know and trusted in the NWP community (such as RTTOV or CRTM).
MF proposes to consider physical-statistical approaches because they can be also applied to sites where reliable first guesses (e.g. radiosonde) are not available. More advanced products based on other retrieval techniques could be retrieved for a restricted number of sites.
GJ proposes a model-based regression trained using a dataset of simultaneous NWP output profiles and observed Tb. This approach has been tested using the LUAMI data set. This approach may be a first tentative for harmonizing the retrievals at different sites and also offers the advantage to avoid calibrations difficulties and the need of simultaneous radiosonde ascents. The main drawback is that the retrieval is strongly dependent on the model.

b. Error characterization

CD/LU remind that variational approaches, such as IPT and 1DVAR, provide a dynamic estimate of the retrieval error characteristics.
LU shows the error characteristics for temperature and humidity profiles obtained with the MeteoSwisse reprocessed dataset at Payerne. These can be used as static error characteristics for the Payerne and (with some assumptions) other sites. The reprocessing effort was explained in detail; it makes use of collocated radiosonde and therefore can be applied to any site in which MWR and radiosonde are operational.

HA proposed that together with error characteristics, other characteristics should be provided to users, such as averaging kernel, sensitivity to perturbation; Humidity but also temperature profiles from microwave radiometers have non-negligible limitations in terms of vertical resolution and sensitivity. These limitations have to be taken into account in the analysis/interpretation, if not, the profile is misunderstood and considered as useless. It is thus a priority to characterize the profile products and to communicate how they have to be interpreted. If data assimilation is not done with brightness temperatures, but with retrieved profiles, averaging kernels (AVK) have to be considered, if not, a very big uncertainty (smoothing error!) has to be assigned to the profile, in order not to mess up the assimilation system, such that it does not add a lot of information. As linear regression retrievals do not provide AVK's in a straight forward manner, a perturbational approach is suggested, e.g. the analysis of the response in the retrieval to a perturbation in the true profile (simulation framework). Results maybe will be shown at the next meeting.
GJ showed the analysis performed with the LUAMI data set. Temperature, water vapour, and relative humidity profiles retrieved by MWR with the model-based retrieval method were compared with NWP model output. These differences between retrievals and model output could be taken as pseudo-error for the model-based retrievals.
MO: Note that NWP validation is as important as DA. Met services check forecast scores against observations on a monthly basis. Therefore, MWR profile retrievals may easily enter this chain, if easily accessible (maybe BUFR through the GTS), even before the DA efforts start.

5. Metadata & data formats

Currently different MWR delivery observations and retrievals using a variety of file formats. The format of MWR output data should be harmonized. Ideally, numerical data should be provided with metadata to facilitate their spread use. The candidate for a common format with metadata should be chosen among the well established and understood by NWP and climate communities data formats.

a. Uniform naming and data formats

LU: The file data naming used for the reprocessing efforts at MeteoSwisse is described. **A sub-working group (SWG) or a training school on the handling and reprocessing of MWR data may be proposed to the MC**.
MO: It would be important to name the measurement products in a uniform way, that is consistent with names used in the NWP and climate communities. The experience at MeteoSwisse is such that MWR retrievals are formatted as radiosonde profiles and thus can be "blindly" ingested into the NWP chain. An estimate of the error and/or quality flags (0/1) should be provided as well in a format similar to that used for radiosondes.
It is recommended to ask the NWP community what file format they would be willing to process/ingest (maybe BUFR through the GTS).
DC: The ARM experience may provide a reference. Data format (NetCDF) and structure/metadata used at ARM could be taken as a starting point. The file naming (e.g. nsamwrpC1.b1.20070215.000635.cdf) reflects site, instrument, data level, date.
CH: Output files by RPG are available in NetCDF, BUFR, a proprietary and documented binary format, as well as ASCI (CSV) format. Data files are divided in lv0 (raw voltages), lv1 (calibrated data, such as TB for the microwave channels, but also IR-temperatures, T/RH/P readings from MET sensors, GPS information, housekeeping data showing internal technical behaviour), lv2 (quality controlled retrieved data obtained from application of a retrieval to lv1 data), lv3 (added-value products).

GJ: Output files by Radiometrics are available in csv (comma-separated-variables). Data files are divided in lv0 (house keeping), lv1 (quality controlled observations), and lv2 (retrievals). Code for converting the csv format into netCDF was developed by users.
The LUAMI experience provides an excellent starting point. Common format was used for both Tb and retrievals. Conversion tools for converting different MWR output files into the common output format (netCDF) were developed by participants (LU, MF, GJ) and are available; these may represent an excellent starting point. It is recommended to develop additional tools to provide retrievals in a simple format to encourage their use by modellers.
MF: The experience of LAUNCH-2005 and LUAMI campaigns are good examples of the use of a common NetCDF data format. During these campaigns an executable converter for the MWR data suitable for windows (available at CNR-IMAA also for Linux) has been provided to the participants. The NetCDF structure adopted during COPS campaign is another good starting point, where metadata as well as added value files were provided.

b. Data flow and storing (central vs. distributed server)
CD: Processing from raw file to products should be performed at a centralized server. This way makes easier to update processing, quality control, data access (upload/download), reprocessing, backups, etc ...
LU: Centralized processing requires enormous efforts from the network headquarter, and therefore distributed processing at single member site should be preferred. This way would distribute part of work on members and less on network headquarter.
MO: Processing should be performed at each member site. This is important because Met services usually want to process their own data and prefer to avoid relying to external data sources.
MF: For providing general high quality products, it is strongly recommended that quality control and calibration monitoring is done in a standardized way in a centralized server.

c. User needs (NWP, climate, radiopropagation applications)
NWP, climate, and radiopropagation are the three communities that should benefit from MWR observations and retrievals. The NWP community is probably the one that may benefit the most, but in order to optimize the efforts, it is recommended to investigate the needs of all these three user communities and understand how these needs may affect our planning on retrieved variables, data format, and meta data.
CD: For NWP applications, EG-CLIMET Working Group D may be enquired about their needs as potential MWR users. A closer contact with GRUAN and COST action IC0802 (“Propagation tools and data for integrated Telecommunication, Navigation and Earth Observation systems”) should be enforced. A presentation about MWRnet was given at one IC0802 meeting.
MF: MWRnet should consider the possibility to meet also GRUAN requirements, above all regarding the “assessment of the uncertainty along the vertical profiles”. Moreover, ARM sonde calibration procedure using the radiometric IPWV could be considered by GRUAN in the future.

6. Towards the establishment of the MWRnet

The establishment of an operational network of MWR depend on the successful achievement of the following steps:
- implementation of common data life cycle (from raw observations to retrieved products)
- off-line experiments demonstrating the value of MWR observations
- establishment of a reliable data flow

DC/LU: it is unlikely that all the above happen without proper funding.

a. Automation of above points (1-5)

There seem to be consensus that the automation of the data life cycle is a long way to go. Therefore the discussion is delayed to next meetings.

b. Funding opportunities

DC/LU: The proto-idea of the MWRnet, based on the MWR operational at the European GRUAN sites only, was proposed to the EU FP7 under the name of the European MicrowavE Radiometer network within GEo (EMERGE). EMERGE passed all the screening steps and was positively judged, although did not reach the funding level. The overall impression was that the call was not ideal for the EMERGE proposal (or the other way around…).
MF: Options like FP7 or other calls should be obviously pursued. However, a closer contact with officers in Brussels is needed in order to understand if there will be future calls that can be more suitable for MWRnet, as nowdays the EU FP7 follows a targeted approach.
Another possible solution for a more rapid establishment of MWRnet could be the use of a different structure. Considering the potential extension of MWRnet, over Europe at least, and the possibility to create a core group working on the data pre- processing and product retrieval, the AERONET model of a federated network of MWR should be considered.
This will allow the establishment of the network using national funded project (in Germany, Italy, the Netherlands, Switzerland, France, UK, etc....) and to offer to all the participating stations the possibility to have processed products released according to an high-level standard as well as the monitoring of the calibration and the quality of their instruments.
Also AERONET policy could be considered for the MWRnet policy. This would require that an institution could be in charge for a centralized database.
Finally, there will be funding opportunities to perform intercomparison or test campaigns by applying to ACTRIS trans-national activities (TNA).

c. Ideas for the future

This first meeting provided first indications on the roadmap to the establishment of MWRnet. Any low-cost initiative that may facilitate this achievement is welcome.
LU: Initiate a flow chart explaining the MWR data life cycle (from raw data to atmospheric retrievals) with an emphasis on sensitive processes (such as calibration, quality control, retrieval,…).
CD: Circulate the idea of a “MWRnet day”. MWRnet members will be kindly required to provide one day worth of data (tentative date 11/11/2011), offline and in their native data format. Code to process the data format into netCDF or other broadly used format is welcome. Data will be stored in one centralized server and will serve as an exercise pool for demonstrating common format, NWP impact, etc,… This effort will build on the LUAMI experience.
GJ: The LUAMI data set already provide a unique dataset that may be used to investigate the impact of MWR data into re-analysis and NWP.

7. Summary and recommendations

The meeting resulted in the following recommendations.

a. MWR data life cycle

#	Type	Recommendation	Note

MM1	Measurement mode	Perform zenith viewing alternating with elevation scans regularly, possibly as frequent as 5 min. Store observations at all channels. If possible, perform 2-side scans.	
MM2	Measurement mode	Perform frequent observations of the calibration load (5min intervals). Use integration time ~10 sec (as calibrations need to have longer integration times than the observations for a safe reduction of rms noise).	
MM3	Measurement mode	Ideally, all raw voltages of receivers and temperatures in the radiometer system should be recorded continuously in order to make a post-calibration possible.	
CC1	Calibration control	Carefully follow instructions for cryogenic calibration. If possible check Tb after cryogenic calibration against a reference (e.g. clear sky radiosonde simulations).	
CC2	Calibration control	Before each cryogenic calibration: observe the cold load for ~2min to characterize the instrument drifts since the last calibration. Note that this need a dedicated featured software since the observed TB will NOT be the LN2 temperature. In fact, the interface reflection on the LN2-surface, residual mirror emission, overspill-termination and other correction factors need to be applied.	
CC3	Calibration control	Be careful when using calibration coefficients obtained by a single sky dip (tipping curve). Make sure the threshold for a horizontally homogeneous sky are set very tight, Averaged time series of sky dip calibration coefficients may be used to avoid jumps in the data. Perform full sky-scans to assess the validity of the "homogeneous sky" assumption.	
CC4	Calibration control	Inspection by manufacturer every 1.5-2 years is recommended	
CC5	Calibration control	Re-processing of MWR observations and retrievals may be possible if a comparable set of collocated radiosonde profiles is available. Alternatively model analyses could be used.	
QC1	Quality control	Use sanity checks to monitor the reliability of the instrument hardware and thus of observed Tb. Use flags provided by manufacturers as well as developed by users.	
QC2	Quality control	Use quality control checks to estimate the value of retrievals in opaque (rainy) situations. Use flags provided by manufacturers as well as developed by users.	
QC3	Quality control	Rain flag is necessary, especially for humidity,	

		but is may overkill acceptable retrievals. Check the quality of retrievals during rain flagged periods.	
RA1	Retrieval algorithm	Uniform multi-linear regression (or NN) retrievals based on radiative transfer calculations should be implemented. These are robust to handle and their accuracy is mostly optimized. Alternatively, direct regression retrievals based on the relation between measurements and model output should be considered.	
RA2	Retrieval algorithm	Ideally, a variational approach should be adopted for all the MWR. However, future testing is required – specifically concerning the handling of liquid clouds	
RA3	Retrieval algorithm	The estimate of the retrieval error should be provided.	
RA4	Retrieval algorithm	The estimate of in-depth retrieval characteristics should be provided (averaging kernels, degrees of freedom)	
DF1	Data format	Produce data in a easy-to-share format with metadata.	
DF2	Data format	netCDF format is preferable.	
DF3	Data format	Common data and metadata format will be decided building on the experience of ARM, LUAMI, COPS.	
DF3	Data format	If the proper funding will be available, data should be processed and stored in a reliable and centralized server.	

b. Actions

#	Action	On	Status
A1	Propose a SWG or training school on the handling of MWRnet data	LU/CD	
A2	Circulate the idea of a “MWRnet day” and discuss feedbacks	CD	
A3	Engage relationships with EG-CLIMET WG D, GCOS, EUCOS and COST IC0802 to investigate their specific needs	ALL	
A4	Results on perturbation error	HA	