Fifth workshop
on the
GEWEX water vapor assessment

Workshop summary

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1. Overview

The GEWEX Data and Assessments Panel (GDAP) has initiated the GEWEX Water Vapor Assessment (G-VAP) in 2011. The major purpose of G-VAP is to quantify the state of the art in water vapour products being constructed for climate applications, and by this supports the selection process of suitable water vapour products by GDAP for its production of globally consistent water and energy cycle products. Workshops are carried out on an annual basis to discuss recent findings, to further refine the plan and to draft and consolidate the assessment reports. The 5th G-VAP workshop was hosted by the Space Science and Engineering Center (SSEC), University of Wisconsin, Madison, WI, USA and took place at the University of Wisconsin's Lowell Center in Madison on 04 and 05 November 2015. Approximately 25 participants from research institutes, universities and SME (Small and Medium-sized Enterprises, Colorado State U, FU Berlin, SSE, U. Lille, Vanderbilt U., U. Wisconsin), from weather services (AEMET, DMI, DWD, NOAA), from the ground-based and in-situ measurement communities (NOAA) as well as from space agencies (ESA, EUMETSAT) attended the workshop. A list of participants, their affiliations and email addresses are given in Appendix D. The presentations of the 5th G-VAP workshop are available at www.gewex-vap.org.

The main objectives of the 5th meeting were to

- Present and discuss results achieved thus far,
- Decide on next steps of G-VAP in order to finalise remaining open activities,
- Further discuss the draft of the WCRP report on G-VAP, feedback from GDAP and the finalisation of the WCRP report,
- Formulate recommendations for future analysis, e.g., in GDAP context and for the attention of agencies,
- Continuation as, e.g., a "science group on atmospheric water vapour".

The workshop started with a summary from the last workshop, feedback from GDAP, a discussion of data releases by G-VAP and several presentations on data sets which are either already used within the assessment or on the candidate list. Additionally some data sets were introduced that were not considered so far but could possibly still be included. Furthermore, updates were given on G-VAP activities and related work, together with proposals on how to proceed in order to finalise the WCRP report in time. Also, the relevance of information content analysis was emphasised and a proposal on how to consistently handle uncertainties was given. A summary from the 183 GHz workshop was given as well. Finally, recommendations, the replanning and the new time line and the future of G-VAP have been presented and discussed.

The main outcomes of the 5th workshop are summarized as follows:

- The replanning for drafting the WCRP report on G-VAP, the freezing of the data archive and the time line to finalise G-VAP have been confirmed by the workshop (see presentation by M. Schröder et al. on 05 November 2015 at 15:00). Among

others: sectional reports finalised until march 2016, preliminary draft to GDAP in April 2016, and final draft to GDAP in August 2016

- The release of collocated data and data on common grid by G-VAP was endorsed under specific circumstances, see below for details.
- It is envisaged to include the U. of Wisconsin's HIRS data record as it covers more than 30 years and it contains profile information. The data is expected to be available by the end of 2015.
- The proposal to continue G-VAP beyond the acceptance of the WCRP report on G-VAP was well received and the participants are willing to support G-VAP in the future.

The following recommendations have been formulated:

- ***Agencies, PIs: Provide information on input such as precise start and stop dates and number of observations as function of time, e.g., on a monthly basis.***
- ***Agencies, PIs: Provide uncertainty information and assess uncertainty as function of total amounts and others.***
- ***CGMS, Agencies: Dedicated validation archive for all water vapour sensors, also including ship based RS.***
- ***G-VAP supports the ITSC-20 recommendation on the reinstallation of the TPW ARM station.***
- ***G-VAP supports the ITSC-20 initiative to collect SRF data in common format at a common location.***
- ***G-VAP supports the concluding remarks from the workshop on Joint workshop on uncertainties at 183 GHz.***
- ***GEWEX: Continuous support to G-VAP, beyond acceptance of first report.***

Recommendations from previous workshops are recalled in Appendix B. Activities from this and from last workshop are recalled in Table 1 and Appendix A, respectively.

2. Background

This year's 5th G-VAP workshop builds upon four previous workshops held in 2011, 2012, 2013, and 2014. The 1st workshop was hosted by the European Space Agency's European Space Research Institute (ESA-ESRIN) with support from the ESA DUE GlobVapour project in March 2011. This workshop set the general framework for the assessment by agreeing on variables, data records and general procedures to be considered. The workshop summary was published in the GEWEX Newsletter[1]. The 2nd workshop, hosted by Deutscher Wetterdienst and EUMETSAT's Satellite Application Facility on Climate Monitoring (CM SAF) in September 2012 aimed at the consolidation of the G-VAP strategy and the technical implementation. The results of the 2nd GVAP workshop were presented to the first GDAP meeting in Paris, October 2012, where further recommendations were received. The major outcomes of the 2nd workshop and feedback from the first GDAP meeting have also been summarized in the GEWEX Newsletter[2]. Results from these workshops and feedback from GDAP were used for setting up the G-VAP assessment plan. The plan is available at the G-VAP webpage (www.gewex-vap.org).

[1] http://www.gewex.org/gewexnews/May2011.pdf
[2] http://www.gewex.org/gewexnews/Nov2012.pdf

The main outcome of the 3rd Workshop was the consensus about the way forward: finalization of the intercomparison, of the comparison to ground-based and in-situ observations, of the homogeneity, trend and stability analysis using gridded data and of the identification of strengths and reasons for inconsistencies. Additionally, several refinements were suggested in particular the analysis of PDFs using instantaneous data. The major outcomes of the 3rd workshop were summarized in the GEWEX Newsletter[3]. The 4th workshop was hosted by FU Berlin in October 2014. Its main outcome was the definition of the structure of the WCRP report on G-VAP and of the ToR for lead and contributing authors. Many participants volunteered to lead and contribute to sections of the report such that the majority of sections are covered. Several refinements and the next steps have been presented, discussed and agreed upon, in particular the consideration of the nnHIRS data record.

3. Major results

After R. Bennartz and M. Schröder welcomed the participants of the 5th workshop M. Schröder gave an overview on G-VAP, including the science questions and overview tables on available data records (http://gewex-vap.org/?page_id=13), recalled results from the last workshop and the aims of the 5th workshop and provided feedback from the GDAP meeting in Xiamen, China in September 2015. He recalled that the activities, progress and results were well received by GDAP. GDAP strongly encourages writing papers first and then have executive summaries as WCRP report. At the same time GDAP encourages the release of the final report as soon as possible. The new time line (see Schröder on 05 November 2015, 15:00) was accepted and it was offered to review an early version of the report in April 2016. Reviewers will be J. Schulz, B. J. Sohn, and G. Stephens. The release of reformatted data records from G-VAP and the continuation of G-VAP was recommended and well received.

A. Gambacorta provided an overview on sources of uncertainty and a general description of the uncertainty analysis that can be applied to an inverse method and which will show how a retrieval is formally related to the true state of the atmosphere and how various sources of error propagate into the final retrieval product to become part of an "uncertainty estimate". She recommended to thoroughly document the computation of retrieval uncertainty estimates and consider uncertainty estimates in retrieval assessments. It was discussed that the presentation is a good start to reach consensus on a metric to describe and assess retrieval uncertainties. The need for a dedicated validation archive for water vapour missions was stated during discussions. It was commented that not only physical but also statistical retrievals can provide thorough retrieval estimates. X. Calbet started to work on best practices for collocation and to describe associated uncertainties (see his presentation on 04 November after 13:30). T. Reale introduced NPROVS+ and the quality of instantaneous water vapor profiles assessed with NPROVS+. Current capabilities of NPROVS and NPROVS+ have been shown and NOAA HIRS will be implemented next. Currently implemented data records exhibit a strong increase in absolute bias above ~200 hPa. Additionally, feedback to GRUAN will be provided as latest results indicate a dry bias in GRUAN under specific conditions.

[3] http://www.gewex.org/gewexnews/Nov2013.pdf

Updates on candidate satellite data records were given by T. August (IASI), J. Nielsen (GPS-RO), R. Kursinski (GPS-RO), J. Forsythe (NVAP-M), S. Casadio (AIRWAVE), P. Menzel (HIRS, MODIS), R. Preusker (MERIS, MODIS, OLCI), J. Riedi (PODLER) and E. Borbas (MODIS). After an introduction to the EUMETSAT IASI v6 product, T. August emphasised the need to provide uncertainties, to describe the vertical information content and to keep in mind that the uncertainties impact the information content. The information content can be described by an analysis of the degrees of freedom and it is also recommended by T. Trent to compare satellite and sonde measurements on layers spanning every completed degree of freedom. J. Nielsen and R. Kursinski talked about GPS RO data. The high quality of GPS-RO between tropopause and top of PBL (~1 km altitude) was recalled. However, at near surface layers and in particular in stratus regions, in presence of strong gradients at cloud top, super-refraction occurs which leads to a dry bias. Also, the top layers with reasonable quality are around 550 hPa during winter. R. Kursinski showed updated results from his presentation at the last workshop and emphasised that the actual resolution of GPS-RO data is under discussion and likely in the order of 100 km (and not 300 km). A controversial discussion started about the handling of relative humidity larger than 100%. J. Forsythe recalls the challenge of merging multi-sensor data and explored the sampling effect on TCWV time series with the goal to understand break points. S. Casadio introduced the AIRWAVE product which is based on (A)ATSR measurements. The evaluation also includes a comparison to ARSA. Stations with ID 48XXX seem to impact the seeming stability of ERA-Interim. ARSA and ERA-Interim PIs will be contacted. The HIRS and MODIS intercalibrations and products from U. of Wisconsin were introduced by P. Menzel and E. Borbas. HIRS intercalibration of full time series utilises SRF shifts and IASI data and orbital drift impacts are handled by dividing the day into four segments. It was recommended not to use MODIS TERRA water vapour products now due to unresolved calibration issues. R. Preusker introduced a unique retrieval for MERIS, MODIS and OLCI and discussed diurnal variability and representativeness as well as horizontal rolls. Finally, J. Riedi introduced water vapour products from POLDER and their validation. This product has advantages over deserts and snow covered regions. As T. August, he also emphasised the value to assess uncertainties as function of water vapour content.

I. Durre presented recent advances in the multi-station radiosonde archive IGRA. IGRA v2 contains significantly more station data, in particular also data from ships and its temporal coverage was extended backward in time. Monthly means are also available and a homogenisation of the archive is foreseen as well. IGRA v2 is available as beta version at present.

Analysis results were presented by M. Schröder, K. Graw, H. Höschen, L. Shi, R. Bennartz, T. Trent and J. Roman, among others. M. Schröder presented results on using trend analysis as a tool to compare TCWV and water vapour profiles. Results related to the analysis of TCWV have been submitted to J. Appl. Meteor. Climatol. In general and on large scale basis, trends in long-term TCWV data records are significantly different and are generally not matching the expectation, except for the SSM/I based data records. The differences in trends and maxima in standard deviation exhibit substantial spatial coincidence and are frequently caused by changes in the observing system. This is a function of region (most pronounced

over South America, Central Africa and Sahara and also evident in the results based on data from the full archive, see K. Graw presentation) and data record. An intercomparison to station data using Level2 does not exhibit breaks when the break is caused by diurnal sampling. It should exhibit breaks if it is a structural uncertainty and if the distinct region is covered by stations. The analysis of profile data reveals that maxima in trend differences generally occur over the ocean, and not over land as for TCWV. Distinct regions are, besides Central Africa, stratus/subsidence regions, mainly on the southern hemisphere and the southern edge of ITCZ over ocean. Here, regions of maximum standard deviations and of maxima in trend differences generally do not coincide, except for stratus regions off the coast of South Africa. Besides break points and biases the vertical representation contributes to the observed differences. This is striking over stratus/subsidence regions at top of PBL and in the free troposphere over tropical land surfaces. The importance of intensified analysis at stratus/subsidence regions was emphasised during discussion. In all relative comparisons the poles exhibit maximum differences. K Graw presented results from the intercomparison of long-term TCWV and profile data records as well as from the weather type analysis and from the intercomparison of the full archive. The intercomparison reveals structural differences associated with ITCZ position, precipitation/diurnal cycle of clouds and stratus/subsidence. The weather type analysis exhibits noticeable differences. It is however unclear if the differences are caused by the weather type or the type of data record (e.g., reanalysis vs microwave). It is planned to include results from the long-term analysis of TCWV, profiles and T in the final G-VAP report only. The NOAA HIRS (tropics only) and the U. Wisconsin HIRS products will be incorporated if available in 2015. In order to improve our understanding of diurnal sampling biases arising from the diurnal cycle of water vapour H. Höschen analysed the NCAR GNSS data record. The bias associated with polar orbiting observations does not exhibit a strong dependency on latitude, season, or amplitude. Instead, the bias is a function of local time bin pairs and is maximal at 2-4, 14-16 LT and 8-10, 20-22 LT. However, the relative bias is with maximum values of approximately 8% small. R. Preusker carried out a similar analysis, with focus on the equator crossing time of MERIS, and confirmed these results. It was discussed that the diurnal sampling of clouds and precipitation seem to dominate diurnal sampling biases. Nevertheless diurnal sampling biases associated to the diurnal cycle of water vapour might impact trend analysis significantly. L. Shi inter-compared UTH products and assessed their variability and consistency with TCWV. The UTH products (AMSU-B, HIRS, Meteosat) show similar spatial and temporal patterns and correlation patterns to Nino3.4, PDO and NAO. Observed differences can be explained with systematic sampling differences and different weighting functions. For 20°N-20°S, the UTH anomaly time series are mostly in opposite phases from the TCWV and WV anomaly time series, especially over the ocean and there are significant differences in lag correlation patterns between satellite observations of UTH and TCWV. R. Bennartz showed results from an analysis of anomalies and temporal variability in water vapor data records and climate model simulations. The response to Nino34 and PDO is very robust and similar in all datasets. Strongest disagreement is found for AO and NAO, especially climate models do not pick up AO and NAO signals. A publication is planned for 2016. T. Trent is also preparing a publication which is about the analysis of stability using NOAA HIRS, HOAPS and ARSA data. He demonstrated the need for future improvements of HIRS inter-satellite calibration. However, data from 1997-present (no NOAA-12) exhibit high stability. The developed tools

constitute a consistent framework for (re)assessing improvements in NOAA HIRS TCWV data. He also emphasised the need to assess the information content of satellite data. Extreme weather events like flash floods are linked to extreme moisture availability and such extremes are expected to strongly increase over the next decades, as emphasised by J. Roman. The understanding of the uncertainty as a function of TCWV is thus highly important. AIRS and IASI would need to span 15 years in order to reveal trends in the 25-75 percentile but 25 years for the extreme percentiles.

There is strong evidence of bias between in-situ, satellite and reanalysis data at 183 GHz which is a strong function of absorption. H. Brogniez (talk given by M. Schröder) provided a summary from a workshop that was dedicated to improve our understanding of these biases. The conclusions, among others, are: RAOB biases can only explain discrepancies that would arise in the centre of the line. Instrument (satellite) bias is unlikely to explain the observed behaviour. New/continuing lab measurements are strongly encouraged, and exploring new line shape parameterisations should be performed. A stronger coordination between calibration/instruments experts and RT modelers to ensure the RT simulations are really modeling what is actually measured is encouraged. The analysis technique may be a contributing factor meaning uncertainty arising from other sources (e.g. spectroscopy, dimers) may be consistent with the remaining bias. X. Calbet provided updated results for the comparison of GRUAN and IASI data. After a series of improvements, among them differentiating between daytime and nighttime sondes and a consistent application of saturation vapour pressure equations led to consistent differences between both observing systems under nighttime conditions. There is still a small remaining bias for daytime sondes (around 2-3%).

A series of formal aspects have been presented by M. Schröder and were discussed in plenary. First, a discussion on the release of data records by G-VAP was discussed. The release of data on common grid and collocated data was endorsed if no open access to the data is provided. Instead potential users are requested to send an email to the G-VAP co-chairs such that the user can be informed on: version which might be outdated, sampling issues in monthly means, link to original data, application of common masks such as land/sea masks, difference between provided grid and original grid as well as differences in temporal resolution and coverage. Finally, outdated versions will be removed from the archive. Details should be discussed with the SPARC water vapour activity and the chair of the GEWEX cloud assessment.

An overview of recommendations was given by M. Schröder and the results from the plenary discussion let to the recommendations given in sections 1 and Appendix B.

A new time line for the drafting of the final report has been proposed which was accepted by the workshop (see M. Schröder on 05 November 2015 at 15:00). Key deadlines are: get draft sectional reports per section until November 2015, finalise sectional reports until April 2016, submit preliminary draft to GDAP in April 2016, finalise full report and submit final draft to GDAP in August 2016. In order to meet the deadline the following has been agreed upon: Keep the report structure, focus on sections which answer the G-VAP Science Questions, and include executive summaries when analysis is based on case studies and/or if papers have

been submitted/published. Also, it was agreed to postpone the following: General analysis of „short term“ data records, trends in UTH, PDF analysis, and weather type analysis. It was consensus to freeze the data archive in December 2015. Several sectional reports have already been received. All authors are kindly asked to further work on the reports as discussed during the workshop and via email. Some reports are missing and the authors are kindly asked to stick to the new time line.

The proposal to continue G-VAP beyond the submission of the G-VAP report and first ideas on how to do this was well received and endorsed. It was mentioned that the current way of organising the workshops is also appropriate for the future.

Finally, the activities listed in Table 1 were agreed upon.

Table 1: List of new activities.

Activity	Responsible	Comment	Until
Finalise minutes and submit letter to GEWEX Newsletter as well as provide talks	Marc Schröder with support from Frank Fell and K. Graw		November 2015
Finalise sections of WCRP report and provide the draft to co-chairs	Lead authors	With support from contributing authors	March 2016
Inform GRUAN, ARSA and ERA-Interim PI on observed results once analysis has been finalised	X. Calbet, S. Casadio, T. Reale		June 2016
Include GPS-RO data in profile intercomparison of long-term data records down to start of superrefractivity	M Schröder, R. Kursinski		March 2016
Include HIRS record from U Wisconsin and remove MODIS TERRA from archive	M. Schröder, K. Graw, E. Borbas		December 2015
Release of data records on common grid and common period and collocated data.	M. Schröder, M. Lockhoff, T. Reale, T. Trent		October 2016
Prior to data release contact SPARC and C. Stubenrauch to exchange ideas on format and type of data.	Co-chairs		May 2016
Implement a document repository for report drafting	Co-chairs		December 2015

4. Conclusions

The 5th G-VAP workshop was hosted by the Space Science and Engineering Center (SSEC), University of Wisconsin, Madison, WI, USA and took place at the University of Wisconsin's Lowell Center in Madison on 04 and 05 November 2015. Approximately 25 scientists from all over the world participated and nearly everybody contributed with a presentation. The presentations were very interesting and relevant to G-VAP and triggered intense, valuable and constructive discussions. The strong support of the community in terms of report drafting,

dedicated analysis and strategic considerations and the continued participation in the workshops is noteworthy and highly acknowledged.

Several presentations contained an outline of the next steps in order to ensure a timely finalisation of G-VAP, together with an updated time line. The presentations are available online at www.gewex-vap.org. The time line and the next steps as well as the freezing of the data archive were uncontroversial. The recommendations have also been updated (see section 1 and Appendix B). The release of collocated data and data on common grid by G-VAP was endorsed under specific circumstances. The proposal to continue G-VAP beyond the acceptance of the WCRP report on G-VAP was well received and the participants are willing to support G-VAP in the future.

The next workshop will tentatively take place at EUMETSAT headquarters on 22+23 September 2016.

Appendix A List of activities from previous workshops

The list has been updated according to progress and decisions from G-VAP workshops.

Activity	Responsible	Comment	Status
Provide template of WCRP report sections and structure of report to lead and contributing authors	Co-chairs	Provided end of 2014	closed
Draft WCRP report on G-VAP and provide the draft to reviewers/GDAP	Co-chairs	With support from lead and contributing authors	August 2016
Extend long-term (>20yrs) analysis with JRA55 and nnHIRS (expected to be available in October 2014)	Maarit Lockhoff, Marc Schröder	JRA55 and nnHIRS included	closed
Include presentations of previous G-VAP workshops on G-VAP webpage	Frank Fell, Marc Schröder	Continuous	open
Compare breakpoint positions to changes in observing system and gradients in major climate indices, relate breakpoint strength to variance before and after breakpoint time and inform PIs	Maarit Lockhoff	April 2016	open
Analyse consistency between temperature and absolute humidity as well as relative humidity using satellite data records of more than 10 years temporal coverage	Lei Shi	March 2016	open
Draft summary report on information content description, value averaging kernels and collocation uncertainty	Thomas August, Tim Trent	March 2016	open
Address diurnal sampling issues using GNSS data	Heidrun Höschen, Marc Schröder	March 2016	open
Exchange information on metrics, data records and general approaches and include B. Read (L. Shi and M. Schröder) in activity on UTH analysis (UTLS analysis) – joined SPARC and G-VAP activity	Lei Shi, Marc Schröder	June 2016	open
Summarize recommendations and needs as input to a GEWEX letter to agencies	Jörg Schulz, Marc Schröder	After report acceptance	open
Draft assessment plan	Co-chairs	Available online	closed
Clarify framework of potential cooperation with ICARE	Co-chairs	Not needed at present, can be an option for the future.	closed
Establish formal communication link to SPARC	Co-chairs	See summary from 3rd workshop	closed
Establish group to initiate technical implementation	Co-chairs	IDL-based G-VAP tool was	closed

		set up by A. Walter and R. Bennartz	
Prioritise data records	Co-chairs	See assessment plan and minutes of 3rd and 4th workshop	closed
Update data fact sheets according to workshop discussions	F. Fell with support from co-chairs	Updated	closed
Set-up G-VAP webpage	Co-chairs	www.gewex-vap.org	closed
Establish group to advise long-term analysis	M. Schröder, R. Bennartz	Covered by discussion letters in future	closed
Draft data policy	M. Schröder, R. Bennartz	See assessment plan	closed
Analyse trend as function of temporal coverage for exemplary data record (e.g., HOAPS)	Marc Schröder	December 2013	closed
Consolidate details of profile evaluation	Marc Schröder, Tony Reale, Antonia Gambacorta	TR takes the lead, following the assessment plan, limited number of records	closed
Set-up password protected ftp server	Maarit Lockhoff, Marc Schröder	Server has limited space	closed
Contact PIs to get information on long-term calibration uncertainty and number of valid observations per month for full record length	Marc Schröder	Will be formulated as recommendation	closed
Contact data providers to join effort (continuous activity)	Co-chairs	Last update in December 2015	closed

Appendix B List of recommendations and needs from previous workshops.

The list has been adapted according to discussions at the previous workshops. In case of analysis the recommendation is also of relevance to assessments.

- ***Agencies, PIs: Develop and provide PDF based climatology of satellite-based radio-occultation data.***
- ***Agencies, PIs: Analyse differences between observations under all-sky as well as cloudy and clear sky conditions.***
- ***Agencies: Need for continental high quality satellite data records.***
- ***Agencies: Need for inter-calibrated radiance/brightness temperature data records and homogeneously reprocessed instantaneous satellite data records.***
- ***Agencies, PIs: Enhance quality analysis of profile data records over open ocean, in particular over high pressure areas/subsidence areas.***
- ***CGMS/WMO: Achieve consistency among reference observing systems.***
- ***Agencies, GEWEX: Provide water vapour transport product in order to analyse atmospheric dynamics and to evaluate the constancy of relative humidity (e.g., ocean to land transport).***
- ***GRUAN: Include station over tropical land.***

Appendix C Workshop Agenda

G-VAP – Workshop

04 - 05 November 2015

Agenda

Venue:

University of Wisconsin's Lowell Center,
Madison, WI, USA

Version 1.2
09 November 2015

Wednesday, 4th Nov 2015

09:00 – 09:10	Welcome *Bennartz*
09:10 – 09:30	Aims of meeting and feedback from GDAP *Schröder, Shi*
09:30 – 09:50	Public release of "G-VAP data" *Schröder, all*
09:50 – 10:05	Overview on sources of uncertainty and exemplary uncertainty analysis using NUCAPS results *Gambacorta*
10:05 – 10:20	Information content and recent advances in the evaluation of the EUMETSAT IASI product *August*
	Discussion
10:30 – 11:00	Coffee break
11:00 – 12:00 (20 min each)	Quality of instantaneous water vapor profiles assessed with NPROVS+ *Reale*
	Assessing stability of long-term TCWV and water vapour profile data records *Schröder*
	Discussion
12:00 – 13:30	Lunch break
(15 min each)	Recent advances in the generation and utilisation of multi-station radiosonde archives *Durre*
	The ROM SAF temperature and humidity profiles from GPS RO observations *Nielsen*
	An analysis of water vapour PDFs – an important element to better understand sampling uncertainties *Kursinski*
	Collocation: best practices and related uncertainties *Calbet*
	Describing the diurnal cycle of TCWV using ground-based GNSS data *Höschen (presented by Schröder)*
	Discussion

15:30 – 16:00	Coffee break
16:00 – 17:30 (15 min each)	Recent results from analysing the NVAP-M data record *Forsythe* AIRWAVE: An (A)ATSR based TCWV data record from ESA *Casadio* Discussion
17:30	Adjourn

Thursday, 5th Nov 2015

09:00 – 10:30 (15 min each)	The UW SSEC/CIMSS global clear sky infrared moisture products derived from HIRS and MODIS data *Menzel* Consistent retrieval of TCWV from MERIS, MODIS and OLCI *Preusker* Retrieving TCWV from Polder observations and its validation *Riedi* Intercomparison of UTH products and consistency analysis *Shi*
10:30 – 11:00	Coffee break
11:00 – 12:30 (15 min each)	Assessment of climate time series of total column water vapor against various climate indices *Bennartz* Evaluation of a new multi-decade TCWV record from HIRS with focus on stability *Trent (presented by Schröder)* Intercomparison of the water vapour data records *Graw* Changes in the frequency of extreme TCWV events *Roman* Discussion
12:30 – 14:00	Lunch break
14:00 – 14:10	MODIS Terra and Aqua *Borbas*

14:10 – 14:30	A bias in observations in the 183GHz line *Brogniez (presented by Schröder)*
14:30 – 15:00	Recommendations to GDAP, agencies and others *Schröder, all*
15:00 – 15:30	The G-VAP report: replanning and next steps *Schröder, Shi, all*
15:30 – 16:00	G-VAP: A sustained assessment? *Schröder, Shi, all*
16:00 – 16:30	Coffee break
16:30 – 17:00	Wrap-up, next meeting
17:00 – 17:30	AoB
17:30	Expected end

Appendix D List of participants

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