

# **Report on Activities of the WMO RA VI European Regional Dobson Calibration Center (RDCC-E) The Meteorological Observatory Hohenpeissenberg (Germany) and The Solar and Ozone Observatory Hradec Králové (Czech Republic)**

**2005**

## **Introduction:**

The European RDCC-E at the **Meteorological Observatory Hohenpeissenberg (MOHp)/Solar and Ozone Observatory Hradec Králové (SOO-HK)** continued its regular work (service and calibration of operational Dobsons in the European network) in 2005 with the organization and realization of one regular campaign with three instruments in June and two small extra campaigns for refurbished Dobsons in April (D018 and D062) and September (D031). In addition two technicians of the Regional Dobson Calibration Centre Africa, from the South African Waether Service (SAWS) were invited to attend a training course on instrumental work (optical alignment, repair and calibration) during the regular IC campaign at MOHp.

In total 6 European Dobsons got a maintenance service and were calibrated towards the MOHp reference instrument Dobson No. 064. Two of these instruments - the Dobsons No. 018 from Kenya and 031 from the **British Antarctic Survey BAS** as a loan to Ukraine - were undergone a complete refurbishment (replacement of the old fashioned electronics by the new US type, optical and mechanical work), which partly started already in fall 2004. Re-adjustment and calibration of the D018 improved quality of monitoring of the tropical ozone layer at the regional GAW station Nairobi that is performed under the assistance and supervision of experts from the Meteo Swiss. The D018 is now an important instrument that supports also ozone sonde monitoring programme at the Nairobi station..

The problem of the calibration level of the Microtops No. 3128 after ten years of continuous operation at MOHp, could be solved by a factory service and calibration. The traveling Microtops No. 3785 developed a doubtful calibration again.

Spare parts supply of the Dobson community, mentioned in former RDCC-E reports as one of the urgent problems, has again been improved in 2004. A number of new special microamperemeters were purchased. Thus we will be able to replace many of the very old instruments in the network, which obviously reached the end of their lifetime. Several pairs of old mirrors with scratched and contaminated surfaces were re-coated and are available for replacement

The excellent “Dobson – Brewer co-operation” was continued during 2005. Members of expert groups met several times during international meetings (e.g. at the WMO/GAW Brewer Workshop at Delft in the Netherlands, the WMO/GAW SAG for Ozone at Payerne, Switzerland and during the NDSC meeting at Puerto de la Cruz on Tenerife in Spain). Status Quo and future Dobson activities were discussed by experts of DAHC after the SAG Ozone meeting. Comparisons of the long term Dobson and Brewer records from Hohenpeissenberg and Hradec Králové with the latest satellite data sets TOMS-V8 and GOME-WFDOAS

revealed some very interesting features. Some of them have been reached under the EC funded project CANDIDOZ (22002-2005) and presented at international workshops in 2005 (Brewer Workshop in Delft, GAW conference in Geneva, 6ORM in Vienna). The results confirm the importance of measuring the thickness of the ozone layer with different and totally independent instruments simultaneously at well-maintained GAW stations. Specialists from the SOO-HK also contributed substantially to realization of the first regional intercomparison of Brewer spectrophotometers at the El Arenosillo observatory, Spain that was organized by the RBCC-E, Izaña in September 2005.

SOO-HK continued training courses organized in cooperation with WMO for operators of Dobson spectrophotometers from GAW ozone stations located outside RA-VI. This long-term educational programme represents the contribution of RDCC-E to the capacity building on monitoring of the ozone layer in developing countries. In 2004 the programme was extended by a technical assistance provided to selected stations in Africa a special 3-year development project of the Czech Government. In 2005 the assistance was given to by expert missions to GAW stations in Brazil, Egypt and Kenya.

Thus MOHp and SOO-HK have again confirmed, that they are able to meet the demands on maintenance the high quality calibration level in the expanded Dobson network in Europe and also assist in the field of capacity building in other regions. The Quality Assessment/Quality Control (QA/QC-programme of WMO) developed for the global total ozone monitoring network of Dobson spectrometers will be guaranteed by both institutions from Germany and Czech Republic in the RA-VI Region on a long term basis. **Attachment 2** proves the benefit of the Dobson calibration system for the data quality.

The following sections give a description of the offered services, the work done in 2005 including results achieved and the activities planned for 2006. An outlook will outline further intentions in the near future.

### **Offered Services:**

In the following paragraphs the tasks and offered services of the RDCC-E MOHp/SOO-HK are listed with a short description and responsibilities that are given in brackets:

- Maintenance/provision of absolutely calibrated regional reference instruments (D064 at MOHp, D074 at SOO-HK), being regularly compared with standard instruments of the WDCC (NOAA/GMD Boulder, Colorado). These comparisons (as done in June 2002 and February/March 2004) and/or Langley measurements for absolute calibrations should be performed at least every two or three years.
- Technical and scientific organization, performance and evaluation of regular Dobson calibration campaigns at MOHp, until 2003 2 – 3 campaigns per year (each 2 – 3 instruments). From 2004 on only one campaign per year will be held at Hohenpeißenberg (up to 5 instruments which need intensive work). Well maintained Dobsons with minor problems will be gathered once per 4-5 years in larger campaigns (10 instruments in the maximum) organized either at El Arenosillo (Spain) or Arosa (Switzerland) and assisted by RDCC specialists from MOHp and SOO-HK. The reason is that the Hohenpeißenberg facility does not allow to handle more than 5 instruments during one IC. The first larger campaign at El Arenosillo is planned to be held in 2007 (MOHp, SOO-HK).
- Refurbishment of Dobsons being out of operation and/or spectrophotometers that are equipped with old components (e.g. installation of new electronics - theUS style modified by MOHp etc.), supply of spare parts (mainly MOHp with support of SOO-HK). New sources for some special parts (e.g. sun director produced by a Czech workshop, providers of new type of a small and stable SL-power supply, improved and therefore more stable HG-lamps incl. power supply, a modern shutter-motor and a micro-amperemeters) have been found or are under investigation.

- Service for the European Dobson stations, technical/scientific support additional to the regular inter-comparisons (MOHp, SOO-HK) including the provision of a traveling instrument ( e.g. Microtops) for in-situ calibration checks (MOHp).
- Development of new techniques, tools, software and other methods to improve instruments' maintenance, tests, operation and data processing/analyses in cooperation with the WDCC in Boulder, WMO and the Dobson Ad-Hoc Committee (MOHp, SOO-HK).
- Thorough and continuous analyses/control of data quality, support/advice in data re-evaluations, comparisons with other instruments (other Dobsons, other types: e.g. satellite validation), detection/explanation/quantifying of principal differences (e.g. to the Brewer) (MOHp, SOO-HK) in close co-operation with the Dobson Ad-Hoc Committee (DAHC) and the Brewer Ad-Hoc Committee (BAHC) of GAW.
- Preparation and maintenance of Standard Operating Procedures in co-operation with WDCC Boulder, WMO and Dobson Ad-Hoc Committee (MOHp, SOO-HK). Continuous upgrading of the new special Dobson Manual for experts written by Archie Asbridge (MOHp mainly responsible, SOO-HK with advisory function) under the auspices of WMO.
- Education and training of Dobson operators for the regular operation, standard tests and maintenance work both for RA VI and stations located in developing countries including newly established stations with re-located instruments selected after consultation with WMO (SOO-HK).
- Education and training of the own staff of RDCC-E (MOHp, SOO-HK).
- The following equipment (hardware and software) is already available for the above mentioned tasks:
  - Semi-automated two-lamp unit for wedge calibrations (MOHp).
  - Set of spectral lamps for calibration of wavelength setting with Q-levers → Q-tables (MOHp, SOO-HK).
  - Microtops Filter Ozonometer as traveling instrument for in-situ calibration checks (MOHp).
  - Traverse Microscope incl. video system for measurement and adjustment of slit width (MOHp).
  - Special tools like traverse lamp device, 1/3-2/3-device, miniature UV-spectrometer etc. for special tests and alignment procedures (MOHp, SOO-HK).
  - Completely equipped optical laboratory (MOHp).
  - Special Dobson software package for data processing, archiving and transfer, free release and available for users (SOO-HK).
  - Semi-automated PC-controlled facility for reading and processing the Dobson total ozone observations (SOO-HK).
  - Web pages of the Dobson network <http://www.chmi.cz/meteo/ozon/dobsonweb/welcome.htm> (SOO-HK).
  - Stock with selected pieces of spare parts (New US-type electronics, SL- and HG-power supplies, phototubes, microamperemeters, optical components etc.) (MOHp).

Some other stations in Europe also have various tools (spectral lamps e.g. in U.K. and Switzerland), which can be used on demand.

### Activities in 2005:

The RDCC-E MOHp/SOO-HK performed the following activities at various locations in 2005, partly in close co-operation with the WDCC and other RDCC's - responsibilities are given in brackets (**MOHp** = Meteorological Observatory Hohenpeißenberg; **SOO-HK** = Solar and Ozone Observatory Hradec Králové;

**WDCC** = World Dobson Calibration Center at NOAA, Boulder; **RDCC-A** = Regional Dobson Calibration Center for RA I in Africa, South African Weather Service SAWS):

- Maintenance and provision of the two regional reference Dobson instruments No. 064 (MOHp) and No. 074 (SOO-HK).
- Technical and scientific organization, performance and evaluation of one regular Dobson intercomparisons held at the RDCC-E Hohenpeissenberg: MOHp2005 with the D074 (Czech Republic), D084 (Poland) and D0108 (Russia) from June 5 to June 25. Additionally two small extra campaigns were arranged for the refurbished D018 (Nairobi, Kenya), D062 (Arosa, Switzerland) and D032 (Vernadsky in Antarctica, Ukraine). Results of these campaigns are given in **Attachment 1**: Both panels show the difference between the N-values ("raw data") of standard instrument D064 and the Dobsons to be calibrated. Left panel before adjustment during the initial calibration, right panel after adjustment during the final calibration (MOHp, SOO-HK). The right panels always show a significant improvement of the instrumental performance after the final calibration compared with the status of the Dobsons, when they arrived for the intercomparison (left panel) (MOHp, SOO-HK).
- The Microtops filter ozonometer No. 3785 for in-situ calibration checks of Dobsons at their stations was not used for this purpose in 2005. Currently the calibration level of this instruments seems to be not correct again, as ozone values have been low by more than 2% in comparison with the spectrometer. In addition the Microtops instrument No. 3128 was undergone a complete repair and calibration service at Solar Light during July and August 2006 (MOHp).
- Regular calibration services of the Brewers No. 010 (MOHp), 96, 184 (SOO-HK) was carried out by IOS (Ken Lamb, Toronto) in 2005.
- Refurbishment and calibration of D018 was finished in early 2005 at MOHp. Then the instrument was sent back to Nairobi (Kenya) under the responsibility of the Swiss Meteorological Agency (SMA) and installed by the expert from SOO-HK in May. (MOHp, SOO-HK).
- In combination with the above mentioned campaigns two technicians from Switzerland were instructed how to replace the electronics (during MOHp2005-0 with the Swiss Dobson D062) and two technicians of the RDCC-A (SAWS) were trained during the IC MOHp2005 how to check, repair, align and calibrate Dobsons. This training was an important part of the efforts to establish the African RDCC in Pretoria.
- The complete refurbishment (replacement of electronics, optical alignment) of the Ukraine Dobson D031 from the Antarctic station Vernadsky (as a loan of the **British Antarctic Survey** BAS) was finished in 2005 and this instrument then participated in the MOHp2005b-IC in September (MOHp).
- Participation and presentation of contributions on activities of RDCC-E at international meetings:
  - Quadrennial GAW Workshop in Geneva, Switzerland, March 14-16,2005 (SOO-HK, MOHp)
  - The 9. WMO GAW Brewer - Workshop in Delft, Netherlands, May 31-June 3, 2005 (MOHp, SOO-HK).
  - The meeting of the WMO/GAW Scientific Advisory Group for Ozone (SAG-Ozone), Payerne, Switzerland, October 5 - 7, 2005 incl. a DAHC-meeting with discussion of the current state of the Dobson network, future developments e.g. re-location of unused Dobsons to other or new GAW stations, problems at various stations with instrumentation, operation, evaluation of data records and co-operation between Dobson and Brewer groups in the RA-VI, updating of the Dobson Standard Operation Procedures SOP's (MOHp, SOO-HK).
  - The NDSC Steering Committee Meeting, Puerto de la Cruz, Tenerife, Spain, November 7 - 12, 2005 (MOHp).
  - The 6-th Ozone Research Managers Meeting, Vienna, Austria, 19-21 September 2005 (SOO-HK).

- The GCOS Regional Workshop for Eastern and Central Europe, Leipzig, Germany 26-28 April 2005 (SOO-HK)
- Contribution to the drafts of the User Guidance Instructions UGI and Data Quality Objectives DQO, which are initiated by the WMO SAG for Ozone (MOHp, SOO-HK).
- Supervision of the new Dobson station in Armenia, monitoring of the produced data and test results (MOHp).
- Installation and training of observers in operation of the semi-automated recording facilities for Dobson instruments developed and donated to stations in Natal and Cachoeira Paulista (Brazil) and Cairo (Egypt). The missions also included inspection of the Dobson and Brewer monitoring programme at the stations and preparation of the report submitted to WMO/GAW.
- Further development and improvement of the software for controlling the new semi-automated wedge calibration unit (MOHp).
- Maintenance and updating of Dobson Web Pages - an Internet site of the Dobson part of the GAW ozone monitoring network, located at the server of CHMI with the following URL: <http://www.chmi.cz/meteo/ozon/dobsonweb/welcome.htm>. (SOO-HK)
- Further development, production and purchase of necessary RDCC-E tools, equipment and Dobson spare parts (modification of the new US-type electronics, mirror coating, SL-power supplies, shutter motors, sundirectors) (MOHp, SOO-HK).
- Beginning of the arrangement of next Dobson-campaigns to be held at MOHp and Arosa in 2006 (MOHp, SOO-HK).
- Investigation of relation between Dobson, Brewer and recent satellite data sets from collocated measurements performed at MOHp and SOO-HK and their presentation (e.g. the EC funded CANDIDOZ project).
- Evaluation of the 2004-questionnaire. This was helpful for the classification of the instruments' service demands (appropriate to the "simple" medium size calibrations or candidates for more intensive service at MOHp during small campaigns) (MOHp).
- A more detailed investigation of the comparison between MOHp D104/BR010 and the latest TOMS Version 8 confirms the doubts, which were already mentioned in the previous report (s. **Attachment 3**). These findings were presented during the Brewer Workshop and the NDSC SC meeting. This issue was discussed during the WMO SAG ozone meeting and through emails with the responsible NASA scientists (MOHp, SOO-HK).

Expert consultations provided to the newly established Regional Brewer Calibration Centre of RA-VI at Izana, Spain (SOO-HK).

The following staff was responsible for the realization of the above RDCC-E tasks and participated in particular activities:

Dipl. Met. Ulf Köhler, scientific head of the Dobson Calibration Centre (MOHp)  
Dr. Karel Vanicek, head of the SOO-HK  
Dr. Wolfgang Steinbrecht, scientist (MOHp)  
Ing. Martin Stanek, engineer (SOO-HK)  
Ing. Fritz Schönenborn, electronic engineer (MOHp)  
Jiří Pokorný, technician (SOO-HK)  
Bert Dömling, technician (MOHp)  
Ferdinand Strommer, technician (MOHp)  
Alois Stögbauer, workshop (MOHp)  
Hans Eding, electrical workshop (MOHp)

The below listed colleagues participated in the three IC campaigns (in alphabetical order):

Mrs. Malgorzata Bialek, scientist (Inst. of Geophysics, Poland) during MOH2005  
Mr. Franz Herzog, technician (SLF, Switzerland) during MOHp2005-0  
Mr. Gerald Meyer, technician (SAWS, South Africa) during MOHp2005  
Dr. Vjacheslav Privalov, scientist (CAO, Russia) during MOHp2005  
Mrs. Bonawentura Rajewska-Wiech, scientist (Inst. of Geophysics, Poland) during MOH2005  
Dr. Jonathan Shanklin, scientist (BAS, United Kingdom) during MOHp2005b  
Dr. Arkady Shalamyansky, scientist (CAO, Russia) during MOHp2005  
Mr. Piotr Sobolewski, scientist (Inst. of Geophysics, Poland) during MOH2005  
Mr. Danie van der Spuy, technician (SAWS, South Africa) during MOHp2005  
Mr. Reto Wetter (SLF, Switzerland) during MOHp2005-0

## Plans for 2006:

The following list gives an overview about the intended activities to be performed in 2006:

- Technical and scientific preparation, organization, performance and evaluation of one Dobson inter-comparison at MOHp:
  - **MOHp2006-1**, tentatively from June 18 to 30. Expected participants are 4 or maximal 5 instruments: from Germany/Hohenpeissenberg (D104), Greece (D118, Costas Varotsos), Italy (D113, possibly D046, Emanuele Vuerich) and Ukraine/BAS (D103, Steve Colwell) (MOHp).
  - **Arosa 2006**: tentatively from July 10 to 22: The three Swiss Dobsons No.'s 51, 62 and 101 need a calibration after the electronical refurbishment and partly replacement of the wedge. Further candidates are D085 (France) and D047 or D048 (Italy). Reference instrument will be D074 from Hradec Králové (MOHp, SOO-HK).
- Participation in the SAUNA-campaign in Sodankylä (Finland) from March 25 to April 14, 2006. This campaign is to compare different instruments measuring total ozone from the ground with the OMI instrument onboard the AURA-satellite. Participating Dobson instruments will be the standard instruments D064 and D065 (MOHp, WDCC).
- Maintenance of the D064 and D074 spectrophotometers as secondary regional references and the inter-comparison of D064 with D065 (NOAA, WDCC Boulder) at MOHp (MOHp, WDCC) after the SAUNA-campaign.
- Complete refurbishment (at least installation of new US-type electronics), optical alignment and calibration of D103 of the British Antarctic Survey) at Hohenpeissenberg (MOHp) and calibration during MOHp2006-1.
- Complete refurbishment of the D113 instrument (Italy) and calibration during MOHp2006-1, at least begin of refurbishment of D46 (Italy) and possible calibration during MOHp2006-1, if finished until then (MOHp).
- Continuation of the discussion and possible decisions about the further deployment of unused Dobsons (new candidates for a transfer to new stations are instruments from Hungary D120, Italy D046, Belgium D040, Norway D008 and D014) in the frame of WMO/DAHC (WDCC, MOHp, SOO-HK). Transfer of the D035 (UK) to the new station Marion Island (South Africa) is in progress.
- Technical check/adjustment of S049 (former Bordeaux) and upgrade of the software package at the observatory Midi-Pyrenees, France, March 2006, (SOO-HK).
- Training of two Dobson observers from the regional GAW station Nairobi, Kenya, September 2006 (SOO-HK).
- Expert assistance to the intercomparison of Dobson instruments from selected Asian stations at RDCC-Asia, Tsukuba, Japan, March 2006 (SOO-HK).
- Presentation of particular RDCC-E activities at:
  - The meeting of the WMO/GAW Scientific Advisory Group for Ozone (SAG-Ozone), Athens (2), Greece, May 17 - 19, 2006 incl. a DAHC-meeting with discussion of the current state of the Dobson network, future developments e.g. re-location of unused Dobsons to other or new GAW stations, problems at various stations with instrumentation, operation, evaluation of data records and co-operation between Dobson and Brewer groups in the RA-VI, updating of the Dobson Standard Operation Procedures SOP's (MOHp, SOO-HK).

- The NDSC Steering Committee Meeting, Haute Provence, France, September 26 - 29, 2006 (MOHp).

- Further contribution to the UGI (User Guidance Indicators) and DQO (Data Quality Objectives) papers, initiated by WMO SAG for Ozone. In addition an instruction for the application procedure "Dobson Relocation" is under preparation (MOHp, SOO-HK)
- Continuous updating of the Dobson Web Pages with the aim to get comments of visitors and to announce actual events related to the GAW Dobson network; designing and creating a RDCC-E-Web Page at the MOHp-server as a supplement to the Czech web site (SOO-HK, MOHp).
- Further improvement of the technical equipment and software (wedge calibrator, Dobson software package) (MOHp, SOO-HK).
- Further supervision of the Dobson station in Armenia and Kenya and monitoring of the produced data, to ensure the demanded data quality within the global Dobson network (MOHp, SOO-HK).
- More detailed investigations Dobson-Brewer-satellite and Dobson-SAOZ total ozone measurements exploiting the data of the SAUNA-campaign. Presentation of the results at appropriate meetings (e.g. NDSC SC meeting).
- Presentation of the current state of the Dobson (and Brewer) - network at the NDSC Steering Committee Workshop at Haute Provence in September (MOHp).

### **Further Outlook:**

As in the recent years financial problems in most of the countries engaged in the ozone monitoring and research still persist in the short and medium time range of works needed in this important environmental area. Thus following two particular problems, already mentioned in previous Annual Reports, are still on the agenda:

- 1) The continuation of long-term records of total ozone measured with Dobsons is questioned in some institutions.
- 2) The realization of the fundamental requirement of the global Dobson calibration system - the regular absolute calibrations of the standard instruments (at least each two/three years) - is currently very difficult.

Number of unused Dobsons available for a possible relocation is still increasing. Some of these instruments have already found a new location. The discussion of the future operation of the remaining instruments will be continued in the WMO/DAHC and WMO SAG for ozone. Decisions will be made in a close coordination with the lending countries/institutions and the candidates for new Dobson stations. The financial aspects of these transfers could unfortunately not be solved or at least attenuated by means of the submitted but not approved EC funded project EURONET or by another application for the TRAM project. Further efforts are necessary, possibly with the support of WMO/AREP and MP Trust Fund, to raise funds for this important purpose.

The refurbishment and standardization of the instruments remains an important goal for the coming years. The replacement of the large variety of old electronics by the new US-type with MOHp-modification etc. should continue. Each Dobson designated for relocation should be undergone such a renewal. The costs for this activity can partly be covered by the official RDCC-E-budget of the German Weather Service DWD depending on the financial situation of the operating institution/country. In 2006 there is still available the development project of the Czech Government that can be used in the area of the Capacity Building.

The Staehelin's et al.-paper on "Comparison of total ozone measurements of Dobson and Brewer spectrophotometers and recommended transfer functions" (WMO/GAW Report No. 149, WMO TD No.1147,



Geneva, March 2003), initiated also by DAHC, is still a good guidance how to handle the parallel Dobson and Brewer data series created at a considerable number of stations. On the initiative of the WMO SAG for Ozone two papers will be published to improve public information about the quality of measurements of the total ozone column (TOC) by Dobson and Brewer and the available data sets. Drafts have already been prepared of:

- User Guidance Indicators UGI for the TOC data of Dobson & Brewer in the WOUDC/Toronto (Hare)
- Data Quality Objectives DQO of TOC-measurements by Dobson & Brewer (Staehelin, Evans, Köhler, McElroy, Vanicek)

Detailed results of the comparison Hohenpeissenberg and Hradec Králové Dobson/Brewer data with TOMS and other satellite instruments - processed with the latest algorithms Version 8 - confirm the need of a certain number of selected high quality stations, where parallel operation of both types of spectrophotometers are continued (s. attachment 3). These stations are the fundament for reliable validation of satellite data, which will be one of the key activities of the two branches of the GAW total ozone monitoring network with synergetic effects. Further investigations of the principal differences between Dobson and Brewer data series are still very important in this context. The implementation of new findings related to the different temperature dependences of the Dobson and Brewer absorption coefficients in a potential data correction gave encouraging results (s. **Attachment 4**).

The success of the modified calibration scheme without any negative effect on the calibration quality of the European Dobsons will be assessed after the second calibration cycle in about two or three years. The new concept with a combination of annual small MOHp-campaigns for labour-intensive instruments and a quadrennial medium size intercomparison for Dobsons with less demand on repair service has already reduced the amount of necessary work significantly. A first "big" campaign in El Arenosillo (INTA, Spain) is intended to be held in 2007.

Hohenpeissenberg, April 2006

Hradec Králové, April 2006

(Ulf Köhler)

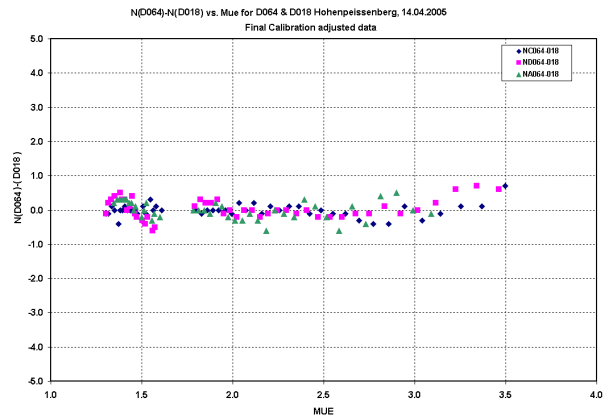
(Dr. Karel Vaniček)

Attachements:

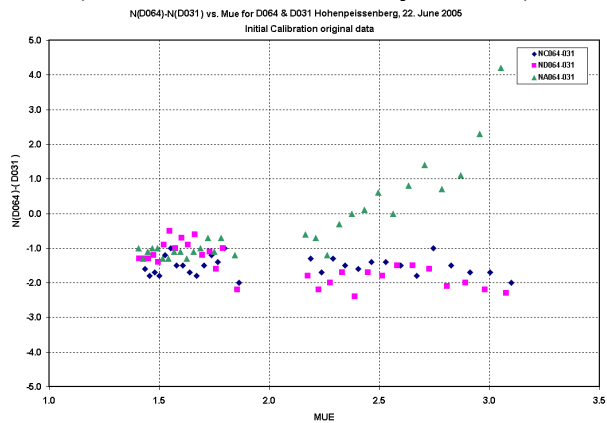
1. Summary graphs of the Dobson calibrations MOHp2005-0, MOHp2005 and MOHp2005b: Initial calibrations of the various instruments on the left hand, final calibrations normally on the right hand (except for D031, which got two final calibrations); shown are the differences of the raw data between standard Dobson and instruments under calibration in the three used wavelength pairs (2 pages).
2. Summary of the success of Dobson calibrations in the past decades.
3. a & b: Relative differences (monthly means) between D104 & BR010 and the VS7- and the latest VS8-data evaluations for the various satellite instruments.
4. a & b: Relative differences (monthly means) between D104 and BR010 (MOHp) original data and with applied temperature- and mue-corrections & between D074 and BR098 (SOO-HK) original data and applied temperature- and SO2-corrections.
5. Actual table of all operational European Dobson stations incl. calibration state and schedule (1 page) for 2005/06.

## Attachment 1: Graphs of the Calibration Results

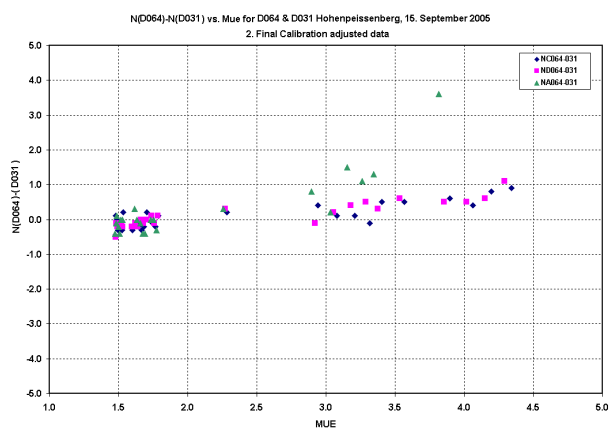
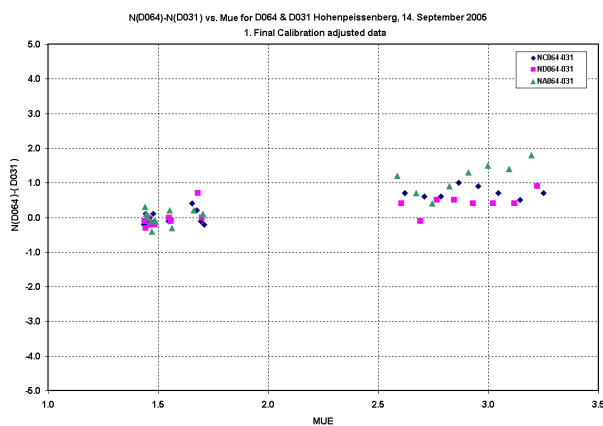
D018 (Nairobi, Kenya) after complete refurbishment - No Initial Calibration possible, as instrument out of operation



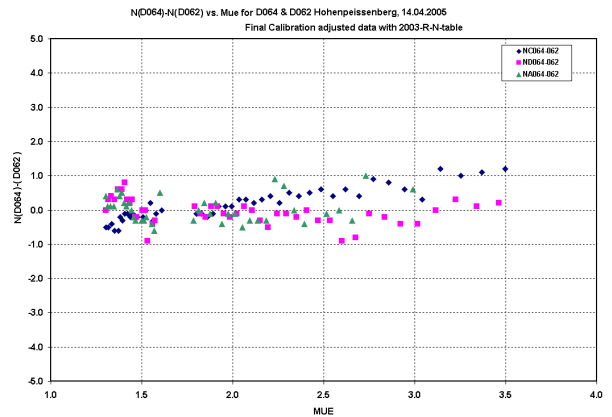
D031 (Antarctic station Vernadsky, Ukraine) after complete refurbishment:



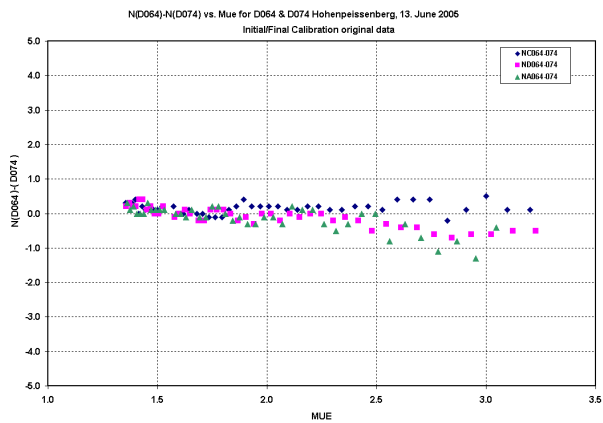
As weather conditions adverse, two days with comparative measurements necessary. Both days provide similar results.



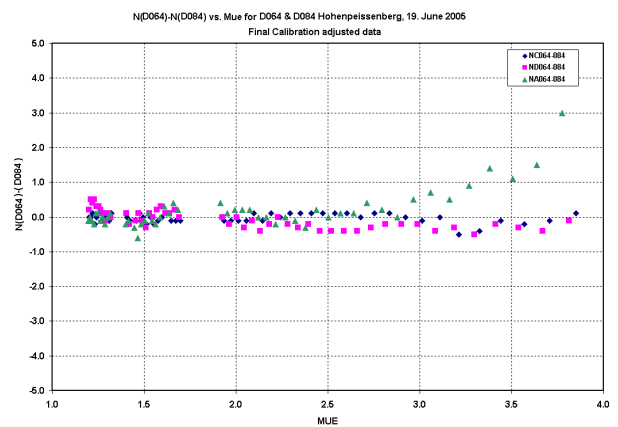
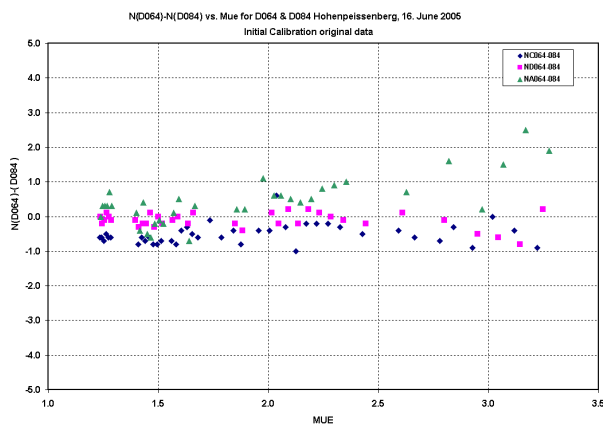
D062 (Arosa, Switzerland) after replacement of electronics (last IC in 2003, therefore no initial calibration necessary):



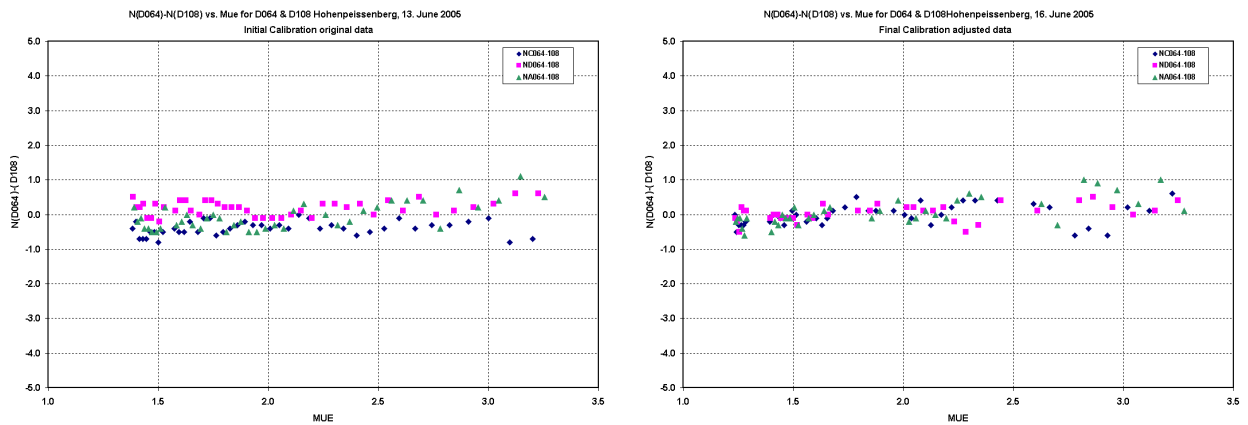
D074 (Hradec Králové, Czech Republic) as second regional reference instrument (last IC in 2002; as initial calibration with excellent results no final calibration necessary)



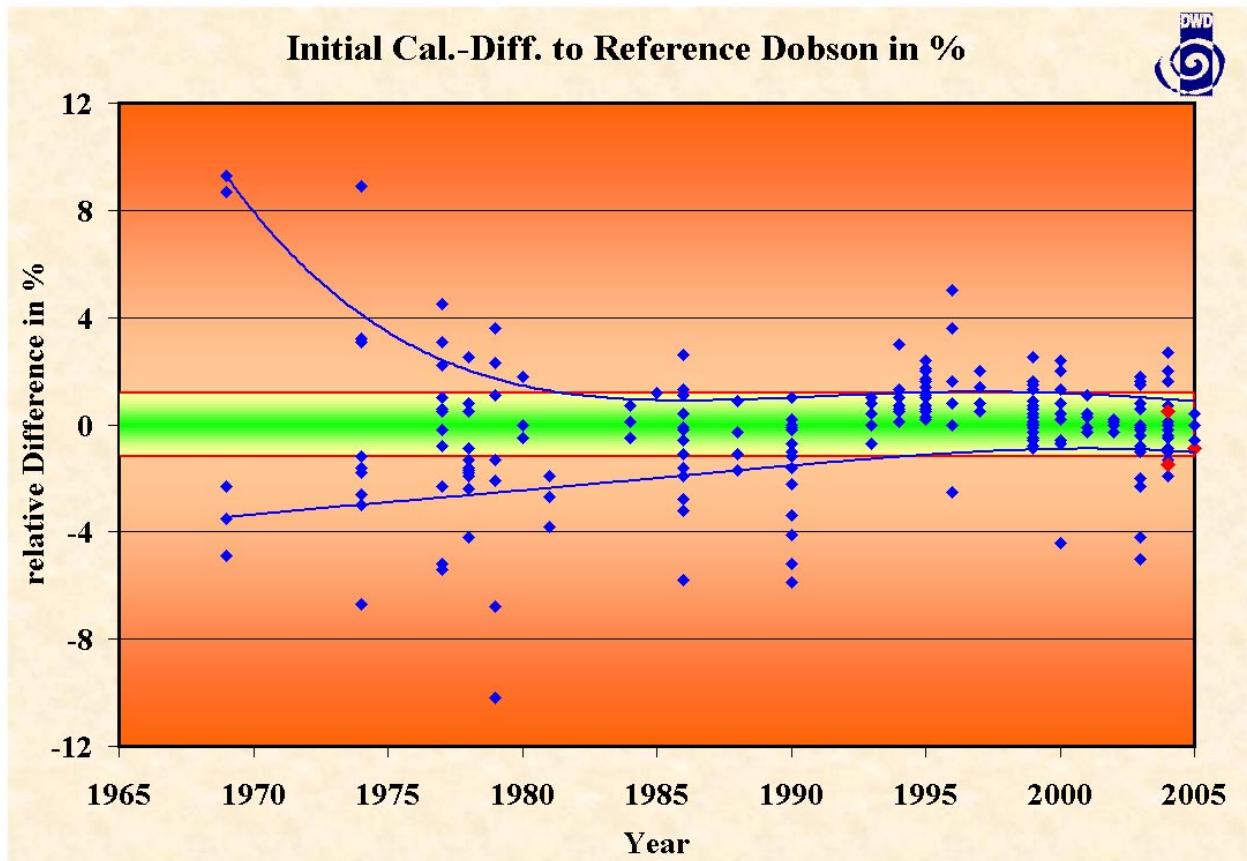
D084 (Belsk, Poland) - regular calibration (last IC in 2001)



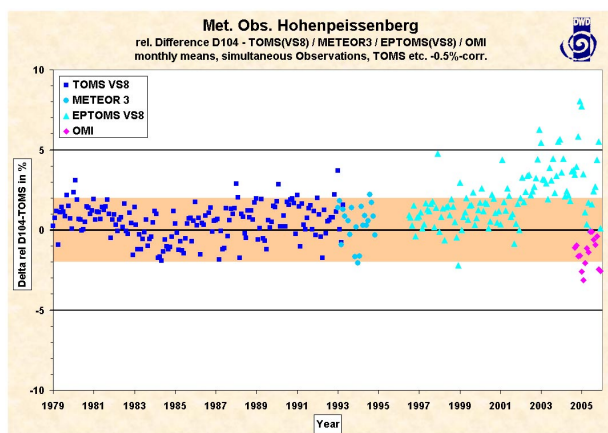
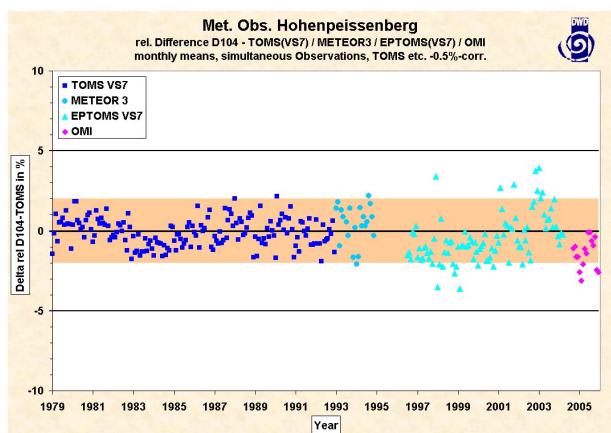
D108 (St. Petersburg, Russia, reference instrument for the Russian filter network) - regular calibration (last IC in 2001)



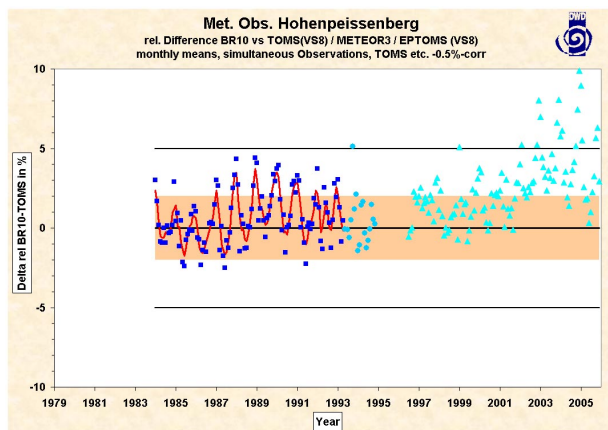
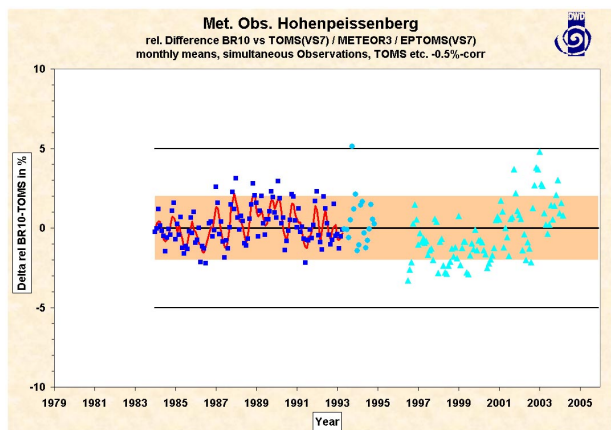
Attachment 2: Dobson calibration success



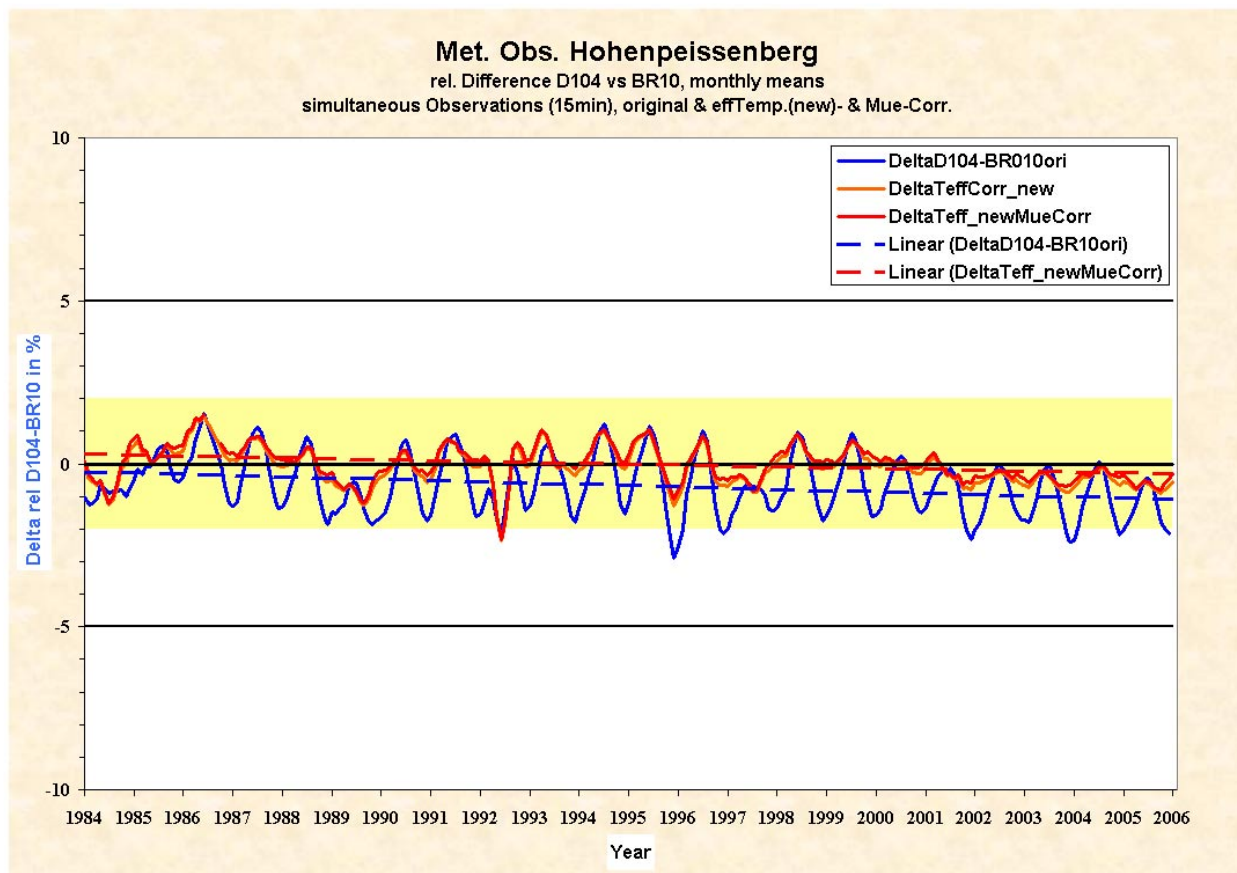
**Attachement 3a: Comparison D104 with various satellite instruments Vs 7 (left panel) & Vs. 8 (right panel)**



**Attachement 3b: Comparison BR010 with various satellite instruments Vs 7 (left panel) & Vs. 8 (right panel)**



**Attachement 4a: Comparison D104 with BR010, blue curve smoothed original data, orange curve with temperature correction, red curve additional with mue-correction (differences in calculation of SZA)**



**Attachement 4b: Comparison D074 with B098, Hradec Králové, 1994-2004 before and after correction of Dobson data for TOeff and total SO2**

