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| **World Meteorological Organization**  **Commission for Instruments and Methods of Observation**  **CIMO Management Group**  **Fifteenth Session** Geneva, Switzerland, 26 – 29 March 2018 | **CIMO/MG-15/Doc. 2.2(5)** |
| Submitted by: B. Forgan  20.03.2018 |

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# Report on progress, recommendations and future activities of the TASK TEAM ON RADIATION REFERENCES

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| **Summary and purpose of document**  This document provides a report on the activities of the Task Team on Radiation References since the CIMO-MG of 2016. |

**Action proposed**

The Meeting is invited to read the report and act on the recommendations.

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**Appendix:** I [Updated Workplan](#Appendix1)

**EXECUTIVE SUMMARY**

* The majority of tasks of the TT have been completed.
* There are no recommendations for a change in the World Radiometric Reference (WRR) or World Infrared Standard Group (WISG) as definitive offsets to SI have yet to be finalized.
* Two experiments, one in Japan and another in Australia, have been completed that examine the difference between windowed pyrgeometers calibrated by PMOD to the WISG and representations of the SI by windowless IRIS instruments traceable to the PMOD blackbody.
* By a comparison between terrestrial radiation measurements and complex radiative transfer models, researchers at the Izania Testbed have corroborated the PMOD/WRC evidence of an 4-5 Wm-2 offset between the WISG and SI.
* A very successful special meeting of the TT focusing on terrestrial measurements was held at the NPL, UK during November 2017. The report will be available in April and will be a useful reference for further work.
* The special TT meeting also recommended a change in the governance of the WISG that was endorsed by CIMO; a governance structure is being drafted.
* Metadata associated with the development of terrestrial radiation measurements are no longer discoverable since the transition of the GCOS/BSRN database from ETHZ to the Albert Wegner Institute and need to be made accessible.
* As a key output network of GCOS and a strong contributor to radiation metrology in the past, BSRN needs to be promoted and supported by CIMO in any WMO commission re-organization.

**REPORT ON ACHIEVEMENTS, RECOMMENDATIONS AND FUTURE ACTIVITIES OF CIMO TASK TEAM on RADIATION REFERENCES**

1. ***Major achievements with respect to Workplan***
   1. Over the current CIMO session there has only been one special meeting of the Task Team, and a number of ad hoc meetings (e.g. during the IPC 2015). Given the nature of the workplan where comparisons or investigations by individuals was required or some work was dependent on other outcomes, face-to-face meetings of the whole Task Team was not considered practical. The special meeting was held in at the National Measurement Laboratory, UK, in November 2017 and focused on terrestrial radiation traceability with attendance limited to a majority of Task Team members and external experts from NOAA, NREL and the Swiss Federal Institute of Metrology. The other ad hoc meetings occurred when members of the TT were at the same location.
   2. All the elements of the workplan that have few dependencies on other activities in the work plan have been successfully completed. Where there are key dependencies, specifically the confirmation of a specific change in traceability to SI for the WRR and WISG, no action has been taken as magnitudes and uncertainties have yet to be finalized.
   3. There has been considerable work at PMOD/WRC related to the WRR-SI relationship, including the continuing development of the cryogenic radiometer to enhance its ability to be used in pyrheliometer comparisons. However, the issue of determining the transmission of the optical windows that preserve vacuum within the cryogenic radiometer is still problematic, and the PMOD/WRC cryogenic radiometer is still unique.
   4. The PMOD/WRC in collaboration with other national metrology laboratories are converging on a difference value between the WRR and SI units of irradiance. However, with the continued development of the cryogenic radiometer a final value for consideration by CIMO and then the EC is yet to be determined. The solar energy community is keen for the offset value to be provided by the EC for their testing environments and solar energy power production applications and have suggested an interim value be recommended to the EC but is not supported by the TT.
   5. Through PMOD and the BSRN investigations on the impact of a scale change for both solar and terrestrial radiation to radiation databases have concluded that implementation could be achieved for the GCOS solar and terrestrial database. The changes for the solar components is a straight forward percentage change for those data bases like the GCOS database where the resolution of the quantity stored is better than 3 significant figures. However, for terrestrial irradiance the problem is complicated by the traceability chain to the WISG, and the PMOD blackbody particularly those instruments whose instrumental characteristics have not been determined in the PMOD blackbody the traceability chain is complex.
   6. The special meeting on terrestrial radiation measurements highlighted over 30 issues related to traceability and field measurements; the report of the meeting is being finalized and should be available in April 2018. The issues reported also suggest ways forward and possible activities for the wider terrestrial radiation measurement community. The meeting was very successful in bringing together representatives of the GCOS measurement community (BSRN), PMOD and the developer of an absolute terrestrial radiometer (NREL). The meeting noted the significant progress in terrestrial radiation measurements since the 1990s under the influence of PMOD and BSRN, and the stability of the WISG since its adoption and an interim terrestrial radiation reference.
   7. Through the work of the field experiments of the TT in Japan and Australia and its collaboration with an intercomparison sponsored by BSRN in the USA, the results are supporting the PMOD evidence of a 4-5 Wm-2 offset between the instruments of the WISG that use filtered domes, and new window-less instruments either absolute instruments or calibrated in the PMOD blackbody.
   8. Recent work published by the CIMO Testbed in Izania that demonstrates the same difference between complex radiative transfer models and instruments calibrated to WISG.
   9. As a result of the compelling evidence of a 4-5 Wm-2 offset, the special meeting recommended increasing the nominal 95 % uncertainty of field measurements promoted by CIMO and BSRN from 5 Wm-2 to 10 Wm-2.
   10. The special meeting of the TT also made detailed examinations of the current traceability chain to the WISG, and the potential to establish a replacement of the WISG using blackbodies and absolute instruments. The outcome was that while there was significant potential in these new instruments and methods, more work needs to be done over the next 3-5 years to ensure a stable and maintainable terrestrial reference can be developed to replace the WISG before any recommendations are made to CIMO or the EC.
   11. Future responsibility for solar and longwave references was examined earlier in this CIMO session by the TT and it was determined that WMO sponsored intercomparisons like the IPC and coincident comparisons for spectral and terrestrial radiometers remain the most effective mechanism to promote traceability in solar and terrestrial radiation measurements. This was further confirmed for traceability of terrestrial radiation measurements during the special meeting of the TT.
   12. The TT was asked to advise WMO if other international and/or national agencies should be responsible and accountable for radiation references. During the current CIMO session the evidence was quite clear that given the specialized nature of solar and terrestrial radiometry, the WMO and its World Radiation Centre remains the most effective organizations to be accountable for solar and terrestrial references. This was supported by the national metrology specialists that attended the special meeting of the TT.
2. ***Problems encountered*** 
   1. When the WISG was established as an interim terrestrial radiation standard by CIMO, PMOD/WRC was given responsibility and authority for the WISG, and it does not have a governance structure similar to the WRR. As the WISG has now been in operation for over a decade and the instruments are used continuously and may fail or need to be replaced to resolve the offset issue instituting a governance structure similar to the WRR was recommended at the special meeting of the TT. A draft governance structure has been produced and could be submitted to the CIMO later this year.
   2. In the development of the agenda for the special TT it became clear that a significant amount of metadata related to terrestrial radiation measurements and decision processes within BSRN appear to be missing as a result of the transition of the GCOS data base from ETHZ, Switzerland to the Alfred Wegner Institute, Germany. These documents need to be recovered if possible and made accessible. The members of the TT that participate in the BSRN meetings will promote the documents restoration at the next BSRN meeting.
   3. Similarly, with the recent proposed changes in organization structures in WMO, future organizational responsibility for BSRN has become clouded, with the current project manager uncertain who to approach. The current BSRN project manager will retire later this year with no clear replacement. At the special TT, there was concern expressed that the BSRN quality requirements for station and data validity that may no longer conform to GCOS principles. Hence it would be prudent for CIMO as a leader in the WIGOS measurement community to assist and support BSRN during the transition to the new structure.
3. ***Recommendations***
   1. At CIMO-17:

- recommend an updated governance structure for the maintenance of the WISG;

- recommend the continuation of the TT for Radiation References with four tasks:  
 . Traceability of solar radiation measurements including the WRR-SI relationship  
 . Traceability of terrestrial (infrared) radiation measurements;  
 . Responsibility to monitor governance of the radiation references;  
 . Liaison with the GCOS/BSRN.

- promote the effectiveness of the IPC and co-incident comparisons;

- promote WMO and PMOD/WRC as the most effective organizations to hold the solar and terrestrial radiation standards.

* 1. Through liaison with the PRC, GCOS and WMO Secretariat the CIMO MG support and promote sustaining the continuity of the GCOS principles in the BSRN.

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**APPENDIX I**

**UPDATED WORKPLAN**

| **No.** | **Task description** | **Person responsible** | **Action** | **Deliverable** | **Deadline for deliv.** | **Status**  **[%]** | **Comments** |
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| 1. | **Traceability of solar radiation measurements - WRR-SI Relationship** | **1. Finsterle, Fox, Monte 2. Finsterle, Fox, Monte 3. Groebner & Tsvetkov** | 1. a.Review and evaluate recent development of reference instruments for solar radiation b. PMOD investigations on Cryogenic radiometer in relation to WRR. 2. a. Assess difference to reference in present use (WRR)   b. Develop recommendations on requirements and timeliness for a modification of the current references (if required develop an implementation plan for the change)   1. Provide advice on the method by which current data bases (WRDC & BSRN) and future IPCs and RPCs can modify support the solar irradiance traceable hierarchy | 1. a. Presentation IPC 2015;. b. Report to CIMO MG 2016 2. a. Progress report. b. Draft recommendation for adoption by CIMO-17 (2018)   3. a. Interim report on potential impact of a small percentage change in the solar reference on solar data bases and users. b. Recommendation on modification of present WRDC and BSRN DB and future submission to reflect WMO solar reference changes. | 1. MG 2016  2. a. MG 16. b. MG 2017  3. a.MG 2016 b.MG 2017 | 1. 100  2. 100  3. NA | CIMO-16, §4.15  Note 1: Indicate whether a WMO endorsed multiplier with an associated uncertainty that relates the WRR to the SI should be introduced.  Note 2: Provide a recommendation on what reference should be used for future solar radiation measurements by WMO Members (if not the WRR, when it  should be introduced)  Note 3: Liaise with respective Euramet project(s)  CIMO-16, §8.6 |
| 2. | **Traceability of terrestrial (infrared) radiation measurements** | **1. Groebner 2. Groebner 3. Groebner 4. Groebner**  **5.ab Ohkkawa 5cd Forgan** | 1. Review and evaluate recent development of reference instruments for terrestrial radiation 2. Assess difference to reference in present use (WISG) 3. Develop recommendations on requirements and timeliness for a modification of the BSRN data bases 4. Provide advice on the potential impacts of the change to stakeholders including changes to be traceability requirements   5. Conduct inter-comparisons at high total column water vapour to examine the impact on infrared measurement traceability | 1. Progress report to CIMO MG 2. A. Progress report b. Report to BSRN community c. Draft recommendation for adoption by CIMO-17 (2018) on future WIR 3. a. Progress report MG 2015 b. Progress report MG 2016 c. Report to BSRN community d. IOM on infrared traceability framework   4.a. Progress report MG 2015 b. Progress report MG 2016 c. Report to BSRN community d. If required updated CIMO Guide section on infrared measurements  5 a. Intercomparison Japan 2015 b. report on Japanese comparison c. Inter-comparison Australia 2015 d. report on intercomparison | 1. MG 2016  2. a MG 2016 b. BSRN 2017 c. MG 2017  3. a MG 2015 b. BSRN 2016 c. MG 2017 d. 2018  4. a MG 2015 b. BSRN 2016 c. MG 2017 d. 2018  5a. report to MG 2016 b. IOM report 2017  c. report to MG 2016 d. IOM report 2017. | 1. 100  2. 80  3. 80  4. 100  5. 100 | CIMO-16, §4.15  CIMO-16, §8.6  Note: Liaise with ET-A3 |
| 3. | **Spectral Irradiance standards** | **Forgan Groebner** | 1. Seek community guidance on the need for WMO to provide a spectral irradiance standards. 2. If desired examine potential focus areas for spectral irradiance standards. 3. If needed a recommendation on the potential spectral irradiance references for operational use by the WMO community. | 1. Hold a session at IPC 2015 to examine the need for spectral irradiance standards. 2. a. Report on progress b. Report on progress c. IOM report 3. Draft recommendation for adoption by CIMO-17 (2018) | 1. MG 2016 2. a. MG 2016 b.. MG 2017 c. 2018 3. 3. MG 2017 | * + - 1. 100 |  |
| 4. | **Future responsibility for solar and longwave radiation references** | **Forgan Finsterle Groebner Fox**  **Monte** | 1. Examine the effectiveness of the inter-comparisons at IPCs to support and sustain the global traceability hierarchy of the WRR and WISG, and the outputs of WMO radiation centres. 2. Advise WMO if it should still define and be accountable for the solar and longwave references embodied in the WRR and WISG, and if not recommend options. | 1. Report on the effectiveness of the comparisons at the IPCs. 2. a. Report on the continuation of responsibility and accountability of solar and longwave reference;   b. If required, a draft transition plan, and  a draft recommendation for adoption by CIMO-17 (2018) | 1. MG 2016 2. a. MG 2016 b.. MG 2017 | 100 | CIMO Guide Part I, Annex 7.C. |

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