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| **WORLD METEOROLOGICAL ORGANIZATION**  **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**  **COMMISSION FOR INSTRUMENTS AND**  **METHODS OF OBSERVATION**  **CIMO MANAGEMENT GROUP**  **Fourteenth Session**  Offenbach, Germany 5 – 8 April 2016 |  | CIMO/MG-14/Doc. 5.1(3)  (29.II.2016)  \_\_\_\_\_\_\_  ITEM: 5.1  Original: ENGLISH |

**OPAG In-Situ Technologies and Instrument Intercomparison**

**REPORT ON PROGRESS AND RECOMMENDATIONS FROM THE CIMO EXPERT TEAM ON INSTRUMENT INTERCOMPARISONS**

(Submitted by E. Vuerich)

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| **Summary and purpose of document**  This document provides information on the progress of tasks assigned to the ET-II and provides suggestions for decisions and recommendations to be considered by the CIMO MG. |

**Action proposed**

The Meeting is invited to review this document and take position on the proposed recommendations and decisions proposed in the document.

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**Appendices:** I Updated Workplan

II Progress report and feasibility study of Upper Air instrument Intercomparison

III Progress report of volcanic ash/aerosol detection intercomparison and annexed document

IV SPICE Project Report

**REPORT ON PROGRESS AND RECOMMENDATIONS FROM THE CIMO EXPERT TEAM ON INSTRUMENT INTERCOMPARISONS**

1. **INTRODUCTION**
   1. The Expert Team on Instrument Intercomparisons (ET-II) is coordinated by the OPAG In-Situ Technologies and Instrument Intercomparison to assist the CIMO Management Group in planning, prioritize, coordinate implementation, review and evaluate global and regional instruments intercomparisons. The achievement of this shared goal is defined by the ET-II Terms of Reference that have been decided by the CIMO and reported in the Annex to paragraph 9.8 of the general summary of CIMO-XVI:

* Prepare and prioritize proposals for instrument intercomparisons (in situ surface, upper-air and marine) according to the CIMO Provisional Programme (2015–2018) and available funds, in particular taking into account the requirements of WIGOS.
* Propose the membership of International Organizing Committees. These will appoint a Project Leader responsible for conducting a specific instrument intercomparison.
* Plan, coordinate implementation, review and evaluate global and regional intercomparisons of instruments and methods of observation in collaboration with relevant manufacturers and the Hydro-Meteorological Equipment Industry Association (HMEI).
* Develop guidance material relevant to the ET ToRs, including proposals for updates of/new chapters for the CIMO Guide.
* Monitor progress of International Intercomparisons through the work of their International Organizing Committees and project teams.

This documents provides information on the development of the ToRs through the approved and updated Work Plan (appendix I).

* 1. The ET on II is coordinated by Emanuele Vuerich (Italian Air Force – Met Service). The ET members are:
* Rodica Nitu (Environment Canada), ET vice-chairperson;
* Yatian Guo (Meteorological Observation Centre, CMA, CINA);
* Florence Besson(Météo France, France);
* Budi Santoso(Agency for Meteorology, Climatology and Geophysics of the Republic of Indonesia);
* Marijn De Haij (KNMI, The Netherlands);
* Wolfgang Finsterle (PMOD/WRC, Switzerland);
* Rolf Philippona (Meteo Swiss);
* Mikko Laakso (Representative of HMEI);
* Carmen Garcia Izquierdo (Representative of BIPM/CCT);
* Timo Ryyppö (Representative of Sodankylä (Finland) Testbed);
* Sangok Han (Representative of Boseong (Republic of Korea) Testbed)
  1. The ET’s members have not yet convened in official meetings, except from “task or opportunity meetings” (some examples: annual SPICE-meetings for WP task no.1, ILRC New York opportunity meeting for instruments intercomparison for volcanic ash/aerosol detection WP task no. 7, etc.). The last two Webex telephone conferences have been held on:
* 10th February 2016
* 3rd March 2016

Next webex teleconference has been planned after the CIMO MG meeting for implementing indications and decisions from MG.

1. **ACHIEVEMENTS WITH RESPECT TO WORKPLANS**

In the following text a short summary of the achieved progresses is provided considering the corresponding assigned task reported in the 2015-updated Work Plan (WP).

* 1. **WMO Solid Precipitation Inter-Comparison Experiment (SPICE) – Task no.1**

The formal field experiments were terminated at the end of the winter season of 2015. Among involved sites, 18 of them have transmitted the data. The data analysis is proceeding, with the focus on technology performance analysis (snowfall and snow on the ground), the derivation of transfer functions for each type of instrument and configuration tested, and the assessment of other science topics of interest (minimum reporting interval, trace precipitation, etc). The final report’s writing will start in earnest in April, when Dr Yves-Alain Roulet (MeteoSwiss) will be completely focused on its preparation in Boulder, CO, USA. The plan is that at the SPICE-IOC-7 meeting (scheduled for 11-15 July 2016 in Toronto, Canada) the results will be ready for review by the team project. The specific purpose of the meeting will be to review the report before limited release for review by manufacturers and other experts who are stakeholders of the project. At the TECO-2016 the SPICE team is planning an extensive presentation of the intercomparison final results, with the publication of the final report later in the year.

The Project Leader, Dr Rodica Nitu, during the last ET telephone conference on the 3rd of March 2016, explained that she is very much confident on the achievements of all main deliverables of the project, in particular: instruments performance evaluation, science results on derivation of transfer function, reporting on operational configurations and field reference configurations, evaluation of the ability to detect light precipitation, assessment of uncertainty, improvements on the measurements of the snow on the ground and the snow water equivalent, and many others.

Moreover during the mentioned webex teleconf, the members agreed on the need of formulating recommendations following the SPICE results for potential future activities, such as regional or national solid precipitation intercomparisons that shall be monitored and reported by/to CIMO through the liaisons mechanisms of the ET-II with other communities or ETs. Update of CIMO Guide related to solid precipitation will be done after the publication of the SPICE Final Report. The ET is also considering updating the CIMO Guide, or another WMO Guide, on the measurement of snow on the ground. To this regard, the ET agreed that part of the SPICE final report will look at CIMO Guide updating.

* 1. **Outcomes of the national China solid precipitation intercomparison – Task no.2**

After the first contacts had in 2014 and 2015, it was not possible to be informed on the outcomes of the national China solid precipitation intercomparison. During the last ET webex teleconf, it was highlighted the importance of such intercomparisons within WMO Regions that represent a priority for network performances and standardization. The task leader Prof. Guo announced he wouldsoon send their results in order to share their findings with the rest of the group. In view of the final report, SPICE project could have benefits from such intercomparisons on national scale.

* 1. **Liaison with other ETs, RAs and communities (BSRN, GAW, WCRP, etc.) on results of and intentions for intercomparisons – Task no.3**

Not many progresses have actually been made for this task.

Dr Finsterle, responsible of the IPC-XII and ET member, advised the group on the intention of Japan to hold a regional radiation intercomparison in January 2017.

The ET Chairman proposes to establish a list of relevant stakeholders/communities contact points (including other ETs and RAs) with the aim of periodically circulating a template communication to get informed on and to share results of/intentions for regional/national intercomparisons. The ET Chairman needs to be assisted by Secretariat/IMO Unit in next weeks to define a simple procedure and use it permanently (also in other intersessional periods).

* 1. **Priorities for future intercomparisons – Task no.4**

The ET members discussed with appreciation that 4 out of 5 priorities for future intercomparison identified by the previous ET-II have been considered by CIMO-XVI in the list of potential intercomparisons 2014 – 2018 with the highest priority and they are part of the current ET WP (tasks no. 1,5,6,7).

Even if it is still early to indicate additional priorities for future intercomparisons in view of CIMO MG or CIMO session decisions, however the ET is considering to stress the need for:

* More numerous and more structured radiation intercomparisons at regional levels are needed and should be encouraged through a new and more efficient way, especially to save resources used for their organization. To this regard, the ET would recall its previous suggestion: *“Coordinated group of regional radiation intercomparisons” involving NRCs and recognized institutions/centres. All together the regional intercomparisons will play the role of an “international intercomparison”, with no need to establish an IOC or allocate many centralized resources, with the centralized assistance/coordination of the ET-II (or ad hoc TT), with involvement of PMOD/WRC-Davos, by applying a centralized and agreed intercomparison and data protocols at the level of the CIMO-MG and ET-II and with an unique Final Report. These should be possibly “combined intercomparisons”: open to all classes of radiometers for global short and long wave radiation + UV radiation and for all seasons (variability of conditions)”.*
* International intercomparison on AWS auto-metar and auto-synop methodologies. Many countries have adopted very different methods, algorithms and QCs. The intercomparison would be mainly focused on methods of observation and report and on procedures/best practices to be applied to obtain effective met observations in AWS and correct codification of data and metadata in meteorological bulletins. This would be a interesting field of investigation and standardization at the level of CIMO and WMO pillar WIGOS. The intercomparison could be organized in a recognized centre/institution where an unique group of met instruments is selected and many AWS are connected to them in order to produce their multiple results. It will be similar to the Radar Algorithms intercomparison that have been recently organized.

Additional suggestions will be provided later in the year.

* 1. **WMO Radiation Intercomparisons – Task no. 5**

Dr Finsterle informed that the IPC-XII at the refurbished World Radiation Centre in Davos (28 September – 16 October 2015) in conjunction with the 2nd international Pyrgeometer comparison and the 4th Filter –radiometer comparison (both coordinated by Dr Julian Gröbner) have all been successfully organized and concluded. Dr Finsterle highlighted the increased numbers of participants in IPC-XII (especially from energy sector and ad-hoc groups). The ET agreed that such approach shall be again encouraged in future.

The Final Report of IPC-XII is expected for publication very soon.

Dr Finsterle, responsible of the IPC-XII and ET member, advised the group on the intention of Japan to hold a regional radiation intercomparison in January 2017.

The proposal from Croatia during the CIMO-XVI to carry out a regional intercomparison of reference pyranometers of the WMO RA VI Members has not yet been confirmed in terms of organization.

* 1. **Instrument Intercomparison for upper air measurements – Task no.6**

In 2015 the Upper Air Instrument Intercomparison Task Team (TT UA-II) have been established by CIMO MG. James Fitzgibbon (NOAA, Sterling Field Support Center, Sterling, VA, USA) has been formally included in the TT as requested during ET webex teleconf on the 8th of April 2015.

The TT UA-II discussed the organizational aspects of the intercomparison during regular webex teleconfs and ad-hoc meetings and it has recently developed an activity report and feasibility study for the organization of the UA-II intercomparison. Such report and the study have been drafted according to a template circulated by ET Chairman and the full text has been prepared and submitted by the task leader Dr Rolf Philippona, and reported in Appendix II for evaluation and approval by CIMO-MG.

The TT UA-II highlighted the importance of such UA intercomparison to have a chance of larger inclusion of Indian and Russian manufactures of radiosondes, to have a new state-of-the-art after the last intercomparison in 2010 (rapid evolution of radiosondes and new models), to investigate procedures and references for more accurate observation of climate change through radiosounding systems. Finally, the UA intercomparisons is a double intercomparison because remote sensing instruments will largely included.

* 1. **Instrument Intercomparison for volcanic ash/aerosol detection – Task no.7**

A Task Team for Volcanic ash/Aerosol detection intercomparison has not been established yet. On the opposite side, several discussions and ad-hoc meetings took place since the beginning within a group of experts on lidars (and celiometers) lead by the ET task leader Dr Besson Florence (Meteo France) and her colleague Jean-Luc Lampin. This group refers itself as LET – Lidar Expert Team.

After its opportunity meeting in New York (July, 2015), the LET group decided to develop an extensive preparatory work in view of the proposal for a TT membership and the development of a feasibility study. This study and the TT establishment have been differed because a publication is currently being prepared as a precursory work. To this regard, the task leader Dr Besson provided the ET with a report on the on-going activities of the LET and the content of this preliminary publication that is expected later this year (presumably in September 2016). Dr Besson also informed the ET that a face-to-face meeting is planned in May in Geneva. The LET and ET will soon inform the CIMO-MG after the meeting on its outcomes.

The report of Dr Besson on preparatory LET activity for the intercomparison is provided in Appendix III for evaluation and approval by CIMO-MG. Minutes of the LET meeting in New York is provided as separated file annexed to this report. Upon task leader’s recommendation, the ET proposes a postponement of the feasibility study of the volcanic ash/aerosol detection intercomparison to mid 2017.

1. **PROBLEMS ENCOUNTERED, RISKS IDENTIFIED**

A major problem encountered was the difficulty to involve the team member Dr Budi Santoso (India) in the activities. The ET concluded that he will not be available for the rest of the mandate. For this reason, a new suitable member should be included, because there is a general lack of availability of other members to be involved in WP task no. 4

1. **SPECIFIC REPORTS REQUESTED BY MG**
   1. None
2. **RECOMMENDATIONS - DECISIONS EXPECTED FROM CIMO-MG**
   1. The following decisions are expected from CIMO-MG at its next meeting:

* Evaluate the closure approach of SPICE project as reported in sec. 2.1.
* Evaluation and validation of the UA-II feasibility study submitted by the TT UA-II leader Dr Philippona and reported in Appendix II.
* Indicate how to proceed for the implementation of the feasibility study of UA-II.
* Evaluate and validate the approach adopted by Dr Besson and its LET group in preparation of the feasibility study and TT proposal of the volcanic ash/aerosol detection intercomparison
* Approve the proposed postponement of the feasibility study of the volcanic ash/aerosol detection intercomparison to mid 2017.
* Indicate any other relevant action with regards to the WP tasks in order to facilitate their achievement within expected times and with expected deliverables.
* Establish a list of relevant contact points with the aim of periodically circulating a template communication to get informed on and to share results of/intentions for regional/national intercomparisons ( details in sec. 2.3).
* Nominate (even if temporarily) an ET member for having the leadership of the goals of WP task no. 4 (priorities for future intercomparisons) and 3 (liaisons).
* Approve the updated Work Plan in Appendix I.
  1. The following recommendations are submitted by ET-II to CIMO-MG-14

Consider the need of:

* More numerous and more structured radiation intercomparisons at regional levels and *“Coordinated group of regional radiation intercomparisons” involving NRCs and recognized institutions/centres* (see more details in sec. 2.4)
* International intercomparison on AWS auto-metar and auto-synop methodologies (see more details in sec. 2.4).

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**APPENDIX I: Workplan of the Expert Team on Instrument Intercomparisons (2014-2018)**(Version: as approved by CIMO-MG-13 in Dec. 2014) – Updated 15 March 2016

| **No.** | **Task description** | **Person responsible** | **Action/Milestone** | **Deliverables** | **Deadline for deliver.** | **Status** | **Comments** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1. | **WMO Solid Precipitation Inter-Comparison Experiment (SPICE)** | **R. Nitu**  E. Vuerich | 1. Monitor progress of SPICE 2. Incorporate guidance material from SPICE Final Report into updates of CIMO Guide | 1. Report to OPAG Chair  2. Updated CIMO Guide | 1. Q2 2016 & Q1 2018   2. Q2 2016 (proposal: Q2 2017) | 1. 80%  2. 5% | CIMO-16 §4.11, 4.21-22, 4.31, 7(7).6, 8.7  Main final SPICE milestones:  SPICE-7 Meeting: Toronto, Canada, 11-15 July 2016 (Final Results and draft final report)  Share results with manufacturesr during summer 2016  TECO-2016: presentation of results  Final Report (late 2016) and Updating CIMO Guide |
| 2. | **Outcomes of the national China solid precip intercomparison** | **Guo Yatian** | 1. Share results and outcomes of China solid precipitation intercomparison | Document on China intercomparison outcomes | Mid 2015  (proposal: Q4 2016) | 1. 0% | After interruption of communication in Dec 2014, new announcement of documentation delivery |
| 3. | **Liaison with other ETs, RAs and communities (BSRN, GAW, WCRP, etc.) on results of and intentions for intercomparisons** | **E. Vuerich,** (to be replaced)  M. de Haij,  Mikko Laasko  with support of all | 1. Liaise with other CIMO ETs and external communities on plans/on-going/completed instrument intercomparisons 2. Collect links to published reports of national/regional intercomparisons   3. Coordinate updates of relevant CIMO Guide chapters related to inter-comparisons with these groups and CIMO Editorial Board as required | 1. Report to OPAG-A Chairs regarding plans for intercomparisons  2. List of relevant web links and ongoing projects  3. Update of relevant CIMO Guide Chapters | 1. Q2 2016 & Q1 2018 2. Yearly in April 3. Q2 2018 | 1. 50%  2. 0%  3. 0% | CIMO-16 §4.11, 4.28, 4.29, 4.30, 4.31, 4.33  Critical:  Need of the nomination of a new responsible for task 3 and 4 |
| 4. | **Priorities for future intercomparisons** | **B. Santoso**  (to be replaced)  with support of all | Assess priorities for future CIMO intercomparisons | 1. Updated prioritized list of future intercomparisons | 1. Dec. 2017 | 1. 0% | CIMO-16, §4.29, 4.33, 7(12).6  Use CIMO-approved shortlist as the basis  Critical: no communications after CIMO-16. Need of the nomination of a new responsible for task 3 and 4 |
| 5. | **WMO  Radiation Intercomparisons** | **W. Finsterle**  B. Santoso | 1. Monitor progress of International Pyrheliometer Comparison XII (28 Sept. – 16 Oct. 2015) 2. Monitor progress of International International Pyrgeometer Comparison II (in tandem with IPC XII) 3. Ensure that final reports of intercomparisons are published as an IOM report 4. Liaise with Regional Radiation Centres on plans for reg. rad. interc. | 1. Report to OPAG Chairs 2. Report to OPAG Chairs 3. IOM Report 4. Report to OPAG Chairs | 1. Q2 2016 2. Q2 2016 3. Q2 2016 4. Q2 2016 | 1. 100%  2. 100%  3. 0%  4. 20% | CIMO-16 §4.11, 4.23-25, 4.29,4.31  IPC-XII and II Pyrgeometer International Intercomparison completed. Reports about to be published. |
| 6. | **Instrument Intercomparison for upper air measurements** | **R. Philipona** & Task Team | Carry out feasibility study | 1. Propose TT membership 2. Proposal(s)/ plan for conducting an intercomparison | 1. Nov. 2014   2. Q4 2015 (effectively Q2 2016) | 1. 100%  2. 80% | CIMO-16 §4.11, 4.27, 4.28, 4.29,4.31, 4.33, 7(12).5  1. CIMO-MG 13 §3.1.10: TT approved  2. Feasibility study delivered in March 2016 |
| 7. | **Instrument Intercomparison for volcanic ash/aerosol detection** | **F. Besson**,  M. de Haij,  & Task Team | Carry out feasibility study | 1. Propose TT membership 2. Proposal(s)/ plan for conducting an intercomparison | 1. Nov. 2014   To be postponed to Q2 2017     1. Q2 2016   To be postponed to Q2 2017 | 1. 50%  2. 0% | CIMO-16 §4.11, 4.28, 4.29,4.31, 5.24  1. CIMO-MG 13 §3.1.10: proposal for TT to be resubmitted asap to CIMO-MG 2015  - Ad hoc meeting: NY, USA, July 2015, for ILRC    2. Feasibility study/proposal to be developed after TT establishment. |

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**APPENDIX II: Progress report and feasibility study of Upper Air instrument Intercomparison**

**WMO-CIMO Upper-Air Instrument Intercomparison**

**TT-UAII Report to WMO-CIMO**

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**1 Introduction**

A Task Team Upper-Air Instrument Intercomparison (TT-UAII) was built in November 2014 to make a feasibility study for a future WMO-CIMO instrument intercomparison for upper-air measurements.

The feasibility study for a next WMO-CIMO UAII was made over the last 12 month by the TT-UAII, and consists of a number of questions that were discussed and answered through email exchange and during a special session at the GRUAN-ICM7 meeting in Matera, Italy, in February 2015.

The feasibility study is handed out to the WMO-CIMO secretariat for the CIMO Expert Team on instrument intercomparisons.

**2 Members of the TT-UAII**

Rolf Philipona, MeteoSwiss, Aerological Station, Payerne, Switzerland

Holger Vömel, UCAR/NCAR, Earth Observing Laboratory, Sounding Group, Boulder, CO, USA

Masatomo Fujiwara, Hokkaido University, Faculty of Environmental Earth Science, Sapporo, Japan

Tim Oakley, WMO-GCOS Implementation Manager, MetOffice, UK

James Fitzgibbon, NOAA, Sterling Field Support Center, Sterling, VA, USA

Alexander Haefele, MeteoSwiss, Aerological Station, Payerne, Switzerland

**3 Feasibility study of next UAII**

**3.1 Background and scope of upper-air instrument intercomparisons**

Radiosondes from different manufacturers are used worldwide at several hundred WMO upper-air stations. The accuracy of radiosondes and the homogeneity of the world upper air network was a matter of concern already more than 50 years ago, at the time of the first international intercomparison. Over the last decades, radiosonde intercomparisons conducted under the auspices of CIMO took place more or less every five years, with the last two intercomparisons in Mauritius Island 2005 , and China 2010. Intercomprisons of radiosonde systems aim at improving the quality and cost-effectiveness of upper air observing systems by providing recommendations on system performances, improvements of instruments and methods of observation, and suitable working references to WMO Members and instrument manufacturers.

The China 2010 intercomparison faced two emerging challenges: on the one hand , there was never in the history of radiosonde intercomparisons such a high number of radiosonde manufacturers (11 manufacturers) participating in the intercomparison, including for the first time three manufacturers from China. On the other hand there was also a need to advise GCOS on radiosondes and systems suitable for use in the GCOS Reference Upper Air Network (GRUAN).

While the intercomparison in China in 2010 was very successful with respect to qualifying the eleven radiosonde systems that were participating at the campaign, the fact that radiosonde manufacturers from large regions of the World like Russia and India did not participate due to different reasons, is clearly a shortcoming and not favorable for improving the quality and homogeneity of worldwide upper-air measurements, which is the major goal of International instrument intercomparisons. In China it was also planned to conduct for the first time a combined upper-air intercomparison between radiosondes and remote sensing instruments. Unfortunately, the CIMO expert team originally supposed to support that work was not available by the time of the comparison and large parts of the data were therefore not analyzed as originally expected. These two shortcomings of the last CIMO upper-air intercomparison will have to be addressed at a future UAII, which hopefully will include manufacturers from the whole World and allow the integration of remote sensing instruments for the benefit of in-situ radiosonde measurements and to broaden and extend upper-air investigations and measurements.

**3.2 Questions raised and discussed by the TT-UAII**

The task team discussed a number of principal questions with respect to a future UAII and came to the following answers:

* *Do we need future WMO upper-air instrument intercomparisons?*

All members of the task team unanimously agree that future UAIIs are needed.

* *What are the reasons for having future WMO-UAIIs in a world of GRUAN activities?*

The members of TT-UAII agree that GRUAN has specific scientific goals rather towards climate change investigations, and that a good balance between weather prediction and climate issues with regard to upper air measurements is needed.

* *Do future WMO-UAIIs need to be in the tropics or can they be made at higher latitudes?*

There are members of the TT-UAII who think that upper-air intercomparisons have to be in the tropics. However, the majority of the members think that a next intercomparison could as well be made at higher latitudes.

* *Are WMO Intercomparisons for radiosondes only or also for remote sensing instruments?*

The majority of the members express that remote sensing instruments should be included as much as possible for the benefit of upper air measurements as a whole. However, the main goal of the intercomparison should be to intercompare radiosonde systems and not remote sensing instruments.

**3.3 Specific questions further discussed**

**3.3.1 UAIIs in the tropics or at higher latitudes**

The most recent radiosonde intercomparisons were always held at tropical sites. The mayor reason was to have high humidity values and a high tropopause at above 16 km and at temperatures down to - 80°C. At mid latitude sites the humidity is not as high, the tropopause is rather at 12 to 13 km and temperatures go down to about - 65°C. However, results from recent intercomparisons show that the largest uncertainties on temperature measurements are not at very low temperature values at the tropopause, but rather at high altitudes. The challenge on temperature measurements at high altitudes is the low pressure, which reduces ventilation of the sensors and favors the radiation effect. Humidity measurements on the other hand are more challenging in the tropics, particularly since rather high humidity can still be measured at high altitudes and at very low temperatures. Humidity measurement during the last intercomparison had considerably larger uncertainties on the different radiosondes than temperature measurements, hence there is still a large potential for improvements. It might be added, that about 80% of the radiosondes are launched outside the tropics.

**3.3.2 UAIIs also for remote sensing instruments**

In a future UAII remote sensing instruments shall be included to assist the radiosonde intercomparison on the one hand and to assess the quality of remote sensing measurements versus a widely accepted reference on the other hand. Further, methods shall be developed to compare remote sensing with in-situ observations under consideration of differences in the observed volume (representativeness). This will be a major outcome and benefit of the combined campaign and set the standard for comparisons under consideration of representativeness and atmospheric variability. Established and emerging remote sensing technologies for meteorological or climatological observations of temperature, humidity and wind profiles shall be the focus. We suggest to consider Doppler, Raman and elastic lidar, radar windprofilers and microwave radiometers.

The remote sensing activities can be prepared in advance and run automatically and unattended during the radiosonde IOP and represent a significant but lower workload than the radiosonde IOP. However, the data analysis is expected to be very labor intensive due to the considerably more complex data evaluation. A very careful planning of the combined measurement campaign is advised in order not to cause interferences with the already challenging radiosonde activities.

**3.4 Goals for a future WMO-UAII**

Following the discussions above the TT-UAII decided on four goals for a future UAII.

1 To bring all the major radiosonde manufacturers of all the different regions of the world together (including Russian and Indian manufacturers).

2 To characterize the individual radiosondes with respect to their **Reproducibility** and to determine the **Uncertainty** of the different measured parameters.

3 To compare the different radiosonde systems to a “**Radiosonde Reference**” (mean of three chosen Traveling Standard Systems).

4 To include for the first time remote sensing instruments for the benefit of upper air measurements as a whole.

**3.5 Strategy to reach the four goals**

**Goal 1:** The aim of an international radiosonde intercomparison is to bring together radiosonde systems that are broadly used and in operation in different countries and regions. Manufacturers should be invited to intercompare radiosondes that are already in operational use and not to test new prototypes. The goal is to intercompare systems of manufacturers that provide the operational radiosondes in all the different regions of the World.

**Goal 2:** The reproducibility can be tested by flying two radiosondes of one system in the same flight. A given number of double flights allows calculation the uncertainty of a system. The goal is to always have double flights for all systems. This means that all manufacturers need to be present with two radiosonde systems. On the other hand they will participate at only half as much flights than in previous intercomparisons, but with two radiosondes in each flight.

**Goal 3:** Previous radiosonde intercomparisons were made without a reference since there is no World reference radiosonde. This is sometimes difficult since individual radiosondes of a particular flight are compared to one specific radiosonde that has been chosen as traveling reference. On different flights often different travelling references are used. The goal for the next UAII is to choose three traveling standard systems and to fly them in each flight, with the average of the three being the reference for the particular flight.

**Goal 4:** As stated above remote sensing instruments shall be included for the benefit of upper air measurements as a whole. This can be achieved if one remote sensing instrument of each established and emerging technology for profiling of the essential variables (temperature, humidity and wind) is included. While this is sensible from a scientific point of view, the political implications must be considered, since this would not include all manufacturers worldwide.

**3.6 Sounding requirements for the next UAII**

At least 16 daytime and 16 nighttime flights should be made with each radiosonde system. With double flights this means that each manufacturer will participate to 8 day and 8 night flights always with two radiosondes. Two systems (4 radiosondes) will be intercompared to the reference (3 radiosondes) in each flight, which makes a total of 7 radiosondes under one large balloon. With 14 radiosonde systems (3 traveling standards including) 56 day and 56 night or 112 flights in total will be needed. With 6 flights per day (every 4 hours) a total of 19 are needed. This means that the campaign would last for 4 weeks and no flights will be made on weekend’s except if certain flights had to be postponed during the week.

**3.7 Estimations of costs and time**

Material costs have been estimated to be on the order of 220 kUS$, of which 100 kUS$ would have to be paid by the manufacturers. The 100 kUS$ paid by the manufacturers would more or less cover the 3 traveling standard radiosondes and specific scientific radiosondes. The 120 kUS$ which have to be paid by external money is mainly for logistics, and ballooning material. With respect to time, a total of 4.5 person year has been calculated overall for the entire intercomparison including costs for the remote sensing instruments. This includes management, administration, sounding, data handling, data evaluation and publication of reports.

**4 Evaluation and results**

Compared to previous upper air intercomparison the next UAII should include all the major radiosonde systems that are used by WMO members in the World. Double sounding will allow investigating the individual systems with respect to reproducibility and allow to calculate the uncertainty of each system. The use of a reference will make comparisons between different flights more representative and will allow to better compare the individual systems. Remote sensing instruments will be included and first demonstration of benefits on intercomparing radiosondes and remote sensing instruments will be shown. The results will be published similar as in 2010 in a WMO report that presents a good overview of the quality and uncertainty of WMO radiosondes as a whole and the individual systems in particular. Further, the standard method to compare in-situ with remote sensing data will be described and first results on the quality of remote sensing instruments will be presented.

**5 Conclusions**

The rising number of radiosonde manufacturers and the fact that manufacturers from important large regions (India and Russia) were not part of the last two intercomparisons is a first reason for having a future UAII. A second reason is related to the rapid evolution of radiosondes and the fact that a large part of the radiosonde manufacturers worldwide produced new radiosonde models, which have not been internationally intercompared since 2010. The third and maybe most important reason is that radiosondes are nowadays not only used for weather prediction but also for climate change observation, which in the context of high quality upper air measurements is important not only for GRUAN specific reference stations but also for the large number of GUAN and WMO upper air stations. Remote sensing instruments are an essential part of the upper air observing system for meteorology and climatology and must hence be included in such an intercomparison. While the inclusion of remote sensing is sensible and feasible, logistical and political aspects require careful planning.

March, 2016 Task Team UAII

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**APPENDIX III: Progress report of volcanic ash/aerosol detection intercomparison and annexed document**

(submitted by ET on proposal of Dr Besson Florence and LET group).

**Instrument Intercomparison for volcanic ash/aerosol detection**

**Report to the CIMO intercomparison group and management group**

Florence Besson the 25th of January 2016

***Context***

Taking into account the context of volcanic ash observation:

* what is feasible to assess in order to give reliable information to aviation concerning ash detection and its density and mass estimates in case of volcano eruption, does not exist,
* Lidars and ceilometers have shown their interest in supplement to satellites, and Numerical Weather Prediction. Some in situ measurements, like photon-counter coupled with radiosondes and aircrafts, have been carried out.
* LIDARs and ceilometers are the only surface instrumentation that are able to give some information but with a LOW uncertainty in term of aerosol presence in clear sky, and an IMPORTANT uncertainty in term of concentration.
* To be able to observe, forecast, and prevent hazard for aviation from volcanic ash, a first goal is to evaluate the value and terms of conditions of “LOW” and “IMPORTANT” concerning the observations by LIDARs and Ceilometers.
* A standard for a Lidars and ceilometers operational use, does not exist and the few manufacturers that are existing on the market sell results that are not yet verified fairly regarding the issue of volcanic ash. An ISO brainstorming is expected to start in 2016 with a different spectrum but without formal comparison or data set.

***Main milestones of the project:***

Philippe Keckhut and myself ( Florence Besson) with the help of Jean-Luc Lampin, have defined a project in two steps:

1. A group of reference searchers in the domain and coming from many WMO regions are writing a document that defines the conditions for comparing lidars and ceilometers. The objective of this group named LET and chaired by Philippe Keckhut , ( Lidar Expert Team- mandate is here  ) is to write a scientific publication that will be the basis for a Task Team (TT) working on the feasibility itself. The target date for the publication is mid 2016
2. The TT should be formally nominated mid 2016, on the basis of the publication and taking into account the others aspects that the feasibility should cover ( algorithms from satellites, in situ measurements, …). The TT of a smaller size, should include some members of the LET and members more specialized in the complementary aspects.

***Past meetings of the LET:***

* Face to face meeting in New York during ILRC from the 8th to the 10th of July 2015 ( minutes are here  )
* Webex of the LET the 20th of November 2015
* Webex of the LET the 18th of December 2015
* Webex of the LET the 11th of January 2016

***Reporting:***

A wiki-site administrated by KNMI is containing the reference documents and the ongoing redaction of the publication. (<https://dev.knmi.nl/projects/wmo-ash> - needs login and password to connect )

The 25th of January, the chapters 1 to 4 are 75% drafted and a webex to complete these chapters and to decide on the following action to succeed in the goal is arranged the 15th of February 2016. There will have 3 more chapters to write. It is possible that a face to face meeting ( with no WMO financial participation) would be the best solution

We are confident in having enough elements to propose some terms of feasibility study in 2017. The date will be precise when 1st the scientific publication will be entirely drafted, 2nd when the TT will have had his first meeting.

***Decisions asked to WMO:***

* validate the mandate of the LET
* validate the project milestones

Separated files:

* *Progress report\_Task7\_March2016.docx (main)*
* *Mandat du LET.docx (annex)*
* *Minutes workshop OMM-final\_Task7-Besson.docx (annex)*

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# Mandate for the Lidar Expert Team (LET)

## Context

WMO would like to know what is feasible to assess in order to give reliable information to aviation concerning ash detection and its density and mass estimates in case of volcano eruption.

Lidars and ceilometers have shown their interest in supplement to satellites, and Numerical Weather Prediction. Some in situ measurements like photon-counter coupled with radiosondes and aircrafts have been carried out.

LIDARs and ceilometers are the only surface instrumentation that are able to give some information but with a LOW uncertainty in term of aerosol presence in clear sky, and IMPORTANT in term of concentration.

To be able to observe, forecast, and prevent hazard for aviation from volcanic ash, a first goal is to evaluate the value and terms of conditions of “LOW” and “IMPORTANT” concerning the observations by LIDARs and Ceilometers.

A standard for a Lidars and ceilometers operational use, does not exist and the few manufacturers that are existing on the market sell results that are not yet verified fairly regarding the issue of volcanic ash. An ISO brainstorming is expected to start in 2016 with a different spectrum but without formal comparison or data set.

WMO needs the upper expertise of famous scientists, specialist in lidars in order to define the possible conditions of a formal evaluation of these instruments taking into account of agreed quality control procedures. Such evaluation could be performed through an inter-comparison campaign with reference known conditions or etalons to be determined.

## The objectives of the group are:

Identify the potential outputs pertinent for volcanic ash detection (1), attribution (2) and quantification (3) provided by lidar and ceilometer systems. Review potential strategies and experimental setup to be deployed to evaluate capabilities of active systems and to characterize their performances depending on weather conditions and to evaluate the uncertainty of the measurements, propose uncontroversial observation methods and quality control. This review would be reported in a scientific report delivered in 2016.

This report will be the entry point of the formal feasibility study.

## Content of the document to be published by the LET:

 The Identified content of the scientific report is

1. VAAC, assimilation
2. Review the actual lidars capabilities in terms of detection (height, low concentration at low level…), type and quantification, the state of the arts for volcanic ash
3. Review the past inter-comparisons
4. Identification of key parameters/products potentially delivered by active sensors for
   1. Detection
   2. Typing
   3. Quantification of volcanic ash Dave, Nobuo
5. Methods for evaluating volcanic ash products provided by active sensors for
   1. Detection
   2. Typing
   3. Quantification of volcanic ash
6. Other interesting lidars characteristics to be explored (still non-operational)
7. Assessments of potential ancillary data

There is one formal responsible named to manage the writing of each chapter.

## Members of the LET

The members are:

P Keckhut (Latmos, France) , A Apituley, D Donovan ( KNMI, Netherlands), N Sugimoto ( NIES, Japan) , P Ristori ( SNM, Argentina), B Demoz, M Adam, M Hicks ( NOAA, USA), L Mona, O Traullé and JL Lampin ( Meteo France, France), F Besson ( Resp for the Feasability study in Intercomparison group WMO-CIMO, Meteo France, France), I Mattis ( DWD, Germany) , B Hartley (.Representative of intercomparison in WMO-CIMO management group, Metservice, New Zeland).

The LET is chaired by Philippe Keckhut.

A management group of the feasibility study composed by P Keckhut, JL lampin and F Besson is chaired by Florence Besson who is responsible to report to WMO.

## Schedule of work

When the scientific document will be completed enough, a formal group covering all the perimeter of the feasibility study will be validated by WMO.

The expected goal for the scientific publication is mid 2016.

This mandate document is proposed for validation to the first CIMO management group meeting in 2016.

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**Lidar Expert Team (LET), WMO feasibility study: workshop in NY 8th to 11th of July 2015**

**Events, working plan and milestones**

In December 2014, the 13th meeting of the WMO-CIMO management group has nominated Météo-France in conducting a feasibility study about an inter-comparison of instruments for the detection of aerosols and volcanic ash.

This was initially focused on lidars and ceilometers. Since WMO-CIMO requested a widening of the scope, space systems and in-situ measurements have been included.

Different groups (task team, expert working group et management group) have been designed with both scientists (experts in Lidars) and meteorologists. Group members are listed in Annex 1.

The working sessions were held in a meeting room of the City College of New York provided by NOAA and well-equipped with a web conference system. The usage of the meeting room on Saturday was ordered by Meteo France with an amount of 1500$.

Planning of the sessions :

* Wednesday, July 8 from 1:00 p.m. to 6:00 p.m
* Friday, July 10 from 16:00 to 20:00
* Saturday, July 11 from 9:00 to 12:30

The sessions have been prepared between Meteo-France representatives and Philippe Keckhut ( Chair of the LET) on Monday afternoon and Thursday morning in order to arrange the agenda, plan the objectives and define the perimeter of the debates.

Attendees in New York :

P Keckhut (Latmos, France) , A Apituley, D Donovan ( KNMI, Netherlands), N Sugimoto ( NIES, Japan) , P Ristori ( SNM, Argentina), B Demoz, M Adam, M Hicks ( NOAA, USA), L Mona, O Traullé and JL Lampin ( Meteo France, France)

Apologized on place, but attending by webconf: F Besson ( Resp for the Feasability study in Intercomparison group WMO-CIMO, Meteo France, France), I Mattis ( DWD, Germany) , B Hartley (.Representative of intercomparison in WMO-CIMO management group, Metservice, New Zeland)

Stéphane Victori, from Cimel and also representative of manufacturers (HMEI) in CIMO-WMO had been invited by WMO Observing and Information Systems Department. He introduced himself as a CIMEL representative and the LET members have considered that he should have to leave on Friday and Saturday in respect with other manufacturers that had not been invited.

The LET has agreed with the need of a clarification concerning the mandate of the group whose members are experts in lidars and are not covering the extended perimeter of the feasibility study. In supplementary the roles and the relations between the groups concerning the feasibility study should be refined. A proposal of the mandate has been drafted, waiting for WMO’s approval.

The deliverable of the LET will be a scientific publication co-signed by the LET members.

The deliverable of the Task Team is the feasibility study requested by WMO-CIMO based on the LET report and on other documents (and) covering the perimeter required.

Waiting for validated minutes of the workshop, the intermediate deliverable – chapters of the publication- are described as followed ( steps 5, 6 and 7 would wait for end of 1 to 4) :

1. Review the requirements (resolution, time, quantity, maximum height, flight level, VAAC, assimilation…) **Dave**, Mariana, Pablo, Micheal, Jean-luc, Lucia
2. Review the actual lidars capabilities in terms of detection (height, low concentration at low level…), type and quantification, the state of the arts for volcanic ash. **Lucia**, Arnould, Mariana, Philippe Ina
3. Review the past inter-comparisons **Ina**, Philippe, Jean-Luc, Mariana, Lucia
4. Identification of key parameters/products potentially delivered by active sensors (**Philippe**) for
   1. Detection Dave, Micheal
   2. Typing Lucia, Dave
   3. Quantification of volcanic ash Dave, Nobuo
5. Methods for evaluating volcanic ash products provided by active sensors (**tbd**) for
   1. Detection
   2. Typing
   3. Quantification of volcanic ash
6. Other interesting lidars characteristics to be explored (still non-operational)
7. Assessments of potential ancillary data

Attendees have agreed about working methods and on objectives. Arnoud Apituley has setup a working framework on the KNMI redline system. Arnoud Apituley also proposed himself to prepare a « letter » in the sense of scientific publications in order to introduce the work and the objectives to reach.

The chapters 1 to 4 have to be achieved until end of October. A meeting should then be arranged as a face-to-face but supplemented by webconf for scientists unable to come. The objectives will be to discuss about progress, difficulties and specific issues and to discuss further the issues of section 5. The place of such meeting is not yet known but Geneva should be convenient.

The other aspects of the debate were technical discussions about pertinent parameters to be evaluated for LIDARs and observation scenarii (section 4).

Here is a preliminary list of pertinent parameters:

**Detection**

Accuracy of range calibration

Altitude range, minimum backscattering of the base of layers, (see WMO and VAC standards, VAC, 6, 13, 20 ?,…)

ISO standard to define OPD may be available in September

**Typing**

Water clouds/aerosols can be used as targets:

Specify ; time and vertical resolutions,

Scenarii

Uncertainty of the particles depolarization estimates and its calibration (WMO and VAC standards, , 6, 13, 20 ?,…)

Wavelengths: color ratio (see the scientific review first)

Qualify what is not ash ?

Uncertainty on lidar ratio from independent measurements of both backscattering and extinction backscatter

**Mass estimates**

From :

- extinction backscatter

- size distribution (research topics)

- with other additional measurements

Size distribution + lidar: extinction backscatter

**Conclusions**

The LET have made interesting progress in actions. The workshop is successful.

Attendees seem to feel fully concerned. The expected work from people who have made the decision to participate in the publication is defined and known.

Philippe Keckhut has chaired the debates with accuracy in remaining attentive listening to the needs of WMO relayed by Météo-France: the comparison of instruments on stage and not the extraction of parameters in order to develop algorithms as needed by UKMO

Météo-France is responsible for writing management synthesis of the meetings (this one is the first one), producing a GANTT of the project, to follow the realization of the actions and to propose a refined mandate of the LET and of the Task Team (TT) to the WMO-CIMO.

People who have been expected in LET and TT but who have not shown their interest in responding to emails, participating or working have to be re-evaluated in term of designation in the groups.

Due to the evolution of the perimeter of the feasibility study between last December and June 2015, the existing of an inter-comparison of spatial algorithms for volcanic ash detection, … the links with spatial aspects and in-situ measurements should be refined. If necessary, scientists of other specialties could join the TT.

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**APPENDIX IV: SPICE PROJECT REPORT**

Dr Rodica Nitu, 14 March 2016

1. **Status:**

* Field experiments concluded in 2015.
* Data analysis is underway; focus: performance reports of sensors under test,  adjustments to be applied to measurements, recommendations for users and for manufacturers, best operational practices.
* WMO is covering data analysis resources for Jan-Sept 2016 (Audrey Reverdin)

1. **Plan**

* All results are expected in a draft format: end of June 2016
* SPICE-7 meeting: July 11-15, 2016, Toronto; review the draft of the final report
* August 2016: Report shared with participating manufacturers:; feedback expected by early Sept 2016.
* At TECO conference, the results of SPICE will be released formally.
* Dec 2016: Final Report publication (following editing, etc)
* Scientific papers: specific topics published prior to the final report;

1. **Risks:**

* July 2016 results will only partially represent the expected results (resource limitations, inconsistencies in data, delays in transfer to the SPICE Archive);
* Not all objectives will be fully addressed: resulting from the unavailability of experienced resources to conduct the analysis.
* Only few papers are published prior to the final report, increasing the pressure for capturing the results in the final report.

1. **Project Outcomes:**

* Recommendations for inclusion in the CIMO Guide, Precipitation
* Proposed new chapter on Snow of Ground: CIMO Guide, or for integration with other WMO Publications on the same topic (e.g. using the GCW framework);
* Input to developing Siting and Sustained Performance Standards for the measurement of Solid Precipitation and Snow on Ground.
* Recommendations and best practices regarding the operational use of automatic instruments, including technical specification recommendations.

1. **Deliverables:**

* Final Project Report published: Dec 2016
* Recommendations for the CIMO guide: in the final report (changes to the CIMO Guide to be developed after the SPICE Report publication)
* Recommendation for the Sustained Performance classification: in the final report.

**NOTE:** the project outcomes may not be fully and explicitly part of the Final Report; additional work will be needed to evolve the SPICE final reports in documents to specifically address the outcomes listed above. I would recommend that these are considered as future work for other ETs (Expert Team on Operational In Situ Technologies; . Expert Team on Developments in In Situ Technologies.

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