1st ACTRIS Cloud Radar Calibration Workshop

Meeting Minutes

28-29 September 2015
University of Cologne, Germany

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Participants
The workshop was attended by 26 researchers from five European countries representing a wide community including universities, research institutes, weather forecast centers and radar manufacturers. This allowed debating the various challenges of cloud radar calibration from different points of views and in relation to the different needs of the communities involved.

Agenda and Focus
The main goal of the workshop was to initiate coordinated cloud radar calibration activities across Europe to ensure high quality and intercomparability of the datasets collected. Since this workshop was the first of its kind in Europe, the was rather broad (see agenda attached at the end of this document). The first day of the workshop was intended to provide an overview of ongoing and planned international and European activities regarding cloud radar calibration. Besides sharing expertise, the first day was also aimed at clarifying terminologies and to identify key questions to be further discussed in working groups on the second day. Topics discussed included: definition and use of reflectivity standards, reflectivity calibration, polarimetric variables, antenna and pointing calibration, long-term calibration techniques and coordination of calibration activities within existing European networks.

Discussions and Main Outcomes

- **What does radar calibration mean?**
  There was a broad agreement that radar calibration in general is a combination of different areas: It includes calibration of the instrument itself (e.g. receiver, transmitter), determination of antenna properties and radome losses, and estimation of atmospheric propagation effects. Only if all aspects are specified accurately can the actual measured Z be utilized e.g. for retrievals. Another agreement evolved during the workshop that the term **calibration** should only be used for techniques which use an external target with known properties, e.g. defined radar cross-section or a calibrated power meter. Several other methods, e.g. using a calibrated radar to check the calibration of another radar (e.g. CloudSat overpass statistics) or forward simulations of Z based on in-situ measured particle size distributions (PSDs) are important and very helpful consistency checks but should not be called calibration techniques. Nevertheless, for ensuring high data quality a combination of both, calibration and consistency checks have been identified to be of key importance.

- **Point Target Calibration**
  The given talks revealed that most groups use point targets like metal spheres or corner reflectors with defined radar cross section to estimate the radar calibration parameters. In this way an end-to-end calibration can be performed in contrast to a combination specific calibrations of each single element. There exists already a variety of carrier systems (balloon, copters, mast) but all these methods are so far only suited to calibrate scanning systems. The implications of using a point target to improve the estimation of volume target properties (i.e. reflectivity factor) where extensively discussed. It was also mentioned that several parameters of the radar equation have been derived for precipitation radars and that they should be reviewed by the community for their applicability to cloud radars. Finally, also the internal data processing can have an influence on the comparability of calibrations and therefore a processing standard should be defined. Over the next years and follow-on workshops this community aims to work on guidelines how to perform proper point target calibrations. Also the possibilities to provide other groups with well tested calibration targets and launching equipment has been discussed.

- **Polarimetry, Antenna, and Pointing Calibration**
  While an accurate estimate of reflectivity factor is for most applications of primary importance, also aspects of how to calibrate and check other relevant radar variables have been discussed. The topics ranged from measuring the antenna pattern with external transmitters or point targets, methods of how to check the cross-polar isolation influencing the quality of LDR measurements to the question of how to validate correct antenna pointing in order to avoid biased Doppler velocity estimates.

- **Long-term calibration monitoring**
  Even a 'perfect' radar calibration once in a while would not guarantee long-term high radar data quality if it is not combined with a continuous monitoring of a variety of radar parameters helping to detect issues of radar stability and drifts. This includes internal parameters like the emitted average power, pulse width and shape, or internal losses. Some of these parameters are already continuously monitored and written in log-files, while others should be periodically checked with external meters. A common agreement on which parameters and at which temporal frequency they should be checked will be discussed in more detail in following meetings; it was agreed that particularly the radar manufacturers should be deeply involved in the discussion. Several other long-term monitoring techniques have been demonstrated including for example seasonal statistics of the radar moments, continuous comparison of measured reflectivity factor which forward simulations of in-situ measured PSDs, statistical comparison with CloudSat or other spaceborne radar datasets, comparisons with collocated radar systems (e.g. an MRR) or regular pointing at an external target (e.g. rotating corner reflector).

- **Ongoing Activities and Perspectives**
  Ensuring high quality of cloud radar datasets is a continuous effort requiring constant learning and exchange of experiences between the European and international cloud radar communities (e.g. the ARM program). It was a general consensus that this community should learn from e.g. the lidar or microwave

radiometer communities that have successfully established sophisticated calibration strategies. The participants further agreed that the cloud radar calibration workshops should be continued in the future and that they should be embedded in the European ACTRIS2 network. This would also provide support to e.g. conduct calibration experiments on emerging calibration super-sites and to better coordinate the activities by the different groups in this field. For this, a list of planned and ongoing activities of the different participants has been collected during the workshop as a basis for future collaborations.

Plans for Future Workshops

The participants agreed that the cloud radar calibration workshop should be continued once per year. A possible follow-on meeting could be held around May/June 2016 at TU Delft or before/after the ACTRIS2 meeting in November 2016. It was also suggested to propose a session during the next ERAD conference on the topic of cloud radar calibration. The overview character of this initial workshop should evolve into a format which includes more in-depths sessions about specific topics like e.g. point target calibration.

ACTRIS Cloud Radar Calibration Workshop
28-29 September 2015

Monday, 28th Sept. 2015:

8:45 – 09:00 Welcome and Logistics

09:00 – 10:00 M**otivation and Overview**
09:00 – 09:30 EU activities, ACTRIS (20min talk + 10min disc., H. Russchenberg)
09:30 – 10:00 Implications of calibration for a cloud radar network (20min talk + 10min disc., E. O'Connor)
10:00 – 10:30 Ongoing and planned activities/interests of WS participants (Discussion)

10:30 – 10:45 Coffee break

10:45 – 11:15 How to define and use a reflectivity standard
Reflectivity standards (calibr. targets, cross section), radar point target vs. volume target equation including definition of parameters (volume, range weighting function, etc.)
(H. Russchenberg, 20min talk + 10min discussion)

11:15 – 12:30 Reflectivity calibration – practical examples
11:15 – 11:30 Tethered balloon scanning MIRA calibration (E. Orlandi)
11:30 – 11:45 Absolute calibration of BASTA 95 GHz radar with mast target (G. Clain)
11:45 – 12:00 Reflectivity closure experiment using profiles from OPC (M. Haeffelin)
12:00 – 12:15 Noise-based calibration of S-band radar and intercomparison with the X-band system (C. Unal)
12:15 – 12:40 Discussion: Uncertainties, comparability, and feasibility of reflectivity calibration methods

12:40 – 13:30 Lunch break

13:30 – 14:15 ARM calibration strategy – (30min talk + 15min disc., P. Kollias via Skype)

14:15 – 15:15 Polarimetry, Antenna and Pointing calibration
14:15 – 14:30 Antenna pattern, LDR and polarimetric calibration for MIRA-STSR (A. Myagkov)
14:30 – 14:45 Radar pointing calibration (S. Kneifel)
14:45 – 15:00 ZDR calibration (E. O'connor)
15:00 – 15:15 Discussion: Uncertainties and comparability of polarimetric and pointing calibration methods

15:15 – 15:30 Coffee break

15:30 – 17:00 Long-term calibration techniques
15:30 – 15:45 Internal MIRA calibrations (G. Peters)
15:45 – 16:00 Internal RPG95-FMCW calibrations (T. Rose)
16:00 – 16:15 Long-term cloud radar calibration monitoring at DWD (U. Görsdorf)
16:15 – 17:00 Discussion: How sufficient are internal calibrations? How often do we need external calibr.? What is the most reliable method to monitor calibration quality?

18:30 Dinner at Hellers Brewery (close to Zülpicher Platz)

Tuesday, 29th Sept. 2015:

09:00 – 09:30 Summary of Day 1 and Introduction/Discussion of working group topics

09:30 – 10:45 How to coordinate calibration activities?
09:30 – 09:45 Possibilities within ACTRIS, calibration centers, COST actions, ESFRI (H. Russchenberg)
09:45 – 10:00 How are calibration activities coordinated for MWRs? (U. Löhnert)
10:00 – 10:15 Planned activities in Paliseau (M. Haeffelin)
10:15 – 10:45 Discussion: Coordination within Europe, exchange with ARM, role of radar manufacturers, which super-sites could become calibration centers

10:45 – 11:00 Coffee Break

11:00 – 12:15 WG 1 Short-term and long-term calibration goals: Develop recommendation for minimum calibration requirements for scanning and zenith pointing radars, which activities should be planed first (within the next 12 months)? Define long-term calibration goals including minimum calibration quality requirements (e.g. Ze accuracy).

12:15 – 13:15 Lunch Break

13:15 – 14:30 WG 2 Calibration guide, Definition of Standards: Can we come up with standardized calibration techniques and provide a calibration guide? How can such a guide be developed? What should be included? Including a guide to estimate calibration bias and uncertainty? Who leads it and who can contributes which part?

14:30 – 14:45 Coffee Break

14:45 – 15:45 WG 3 Intercomparability, Coordination of cloud radar community: How to make different radars (locations, frequencies) intercomparable? Which plans already exist for calibration campaigns and how to inform everybody? Should MRRs or transportable cloud radars be considered as second calibration standard? CloudSat overpass statistics?

15:45 – 16:15 Workshop Recap: Feedback, How to improve design/structure of future WS. What was good or not so good? Missing discussion topics and ideas? When/Where shall we continue with these workshops?

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