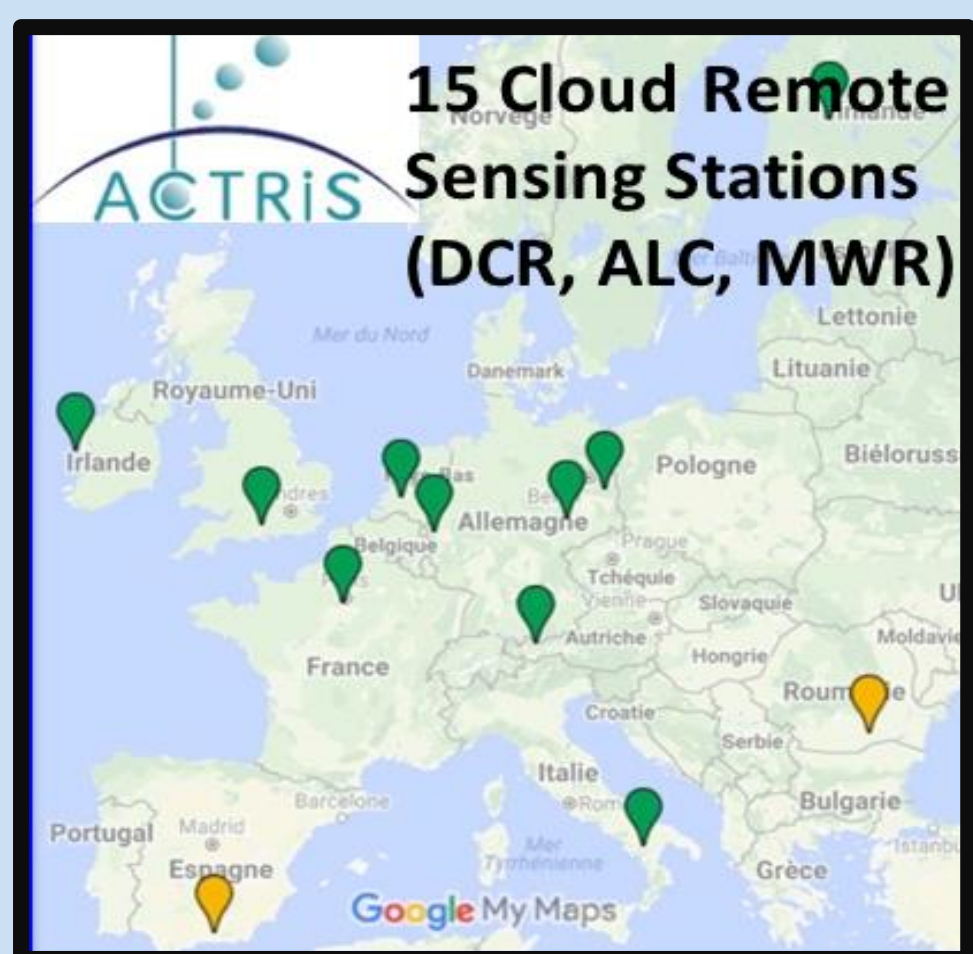


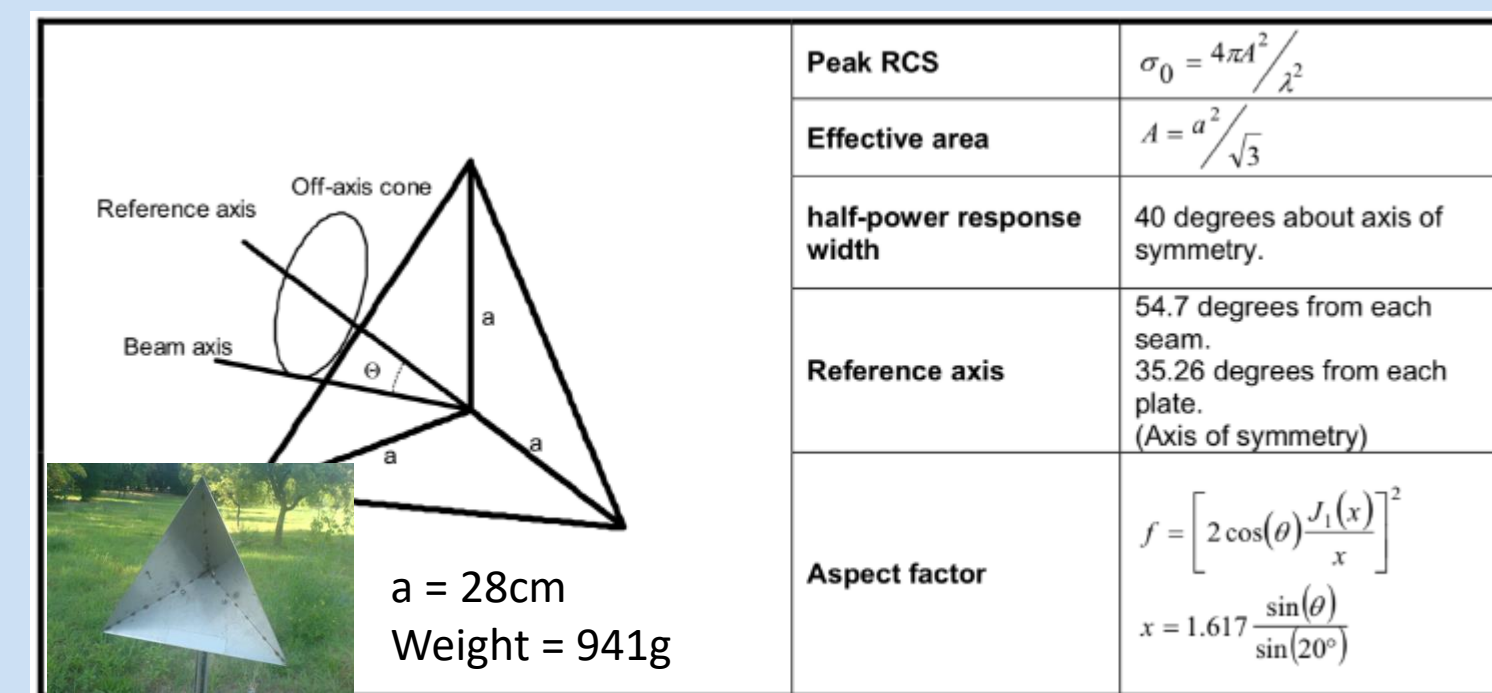
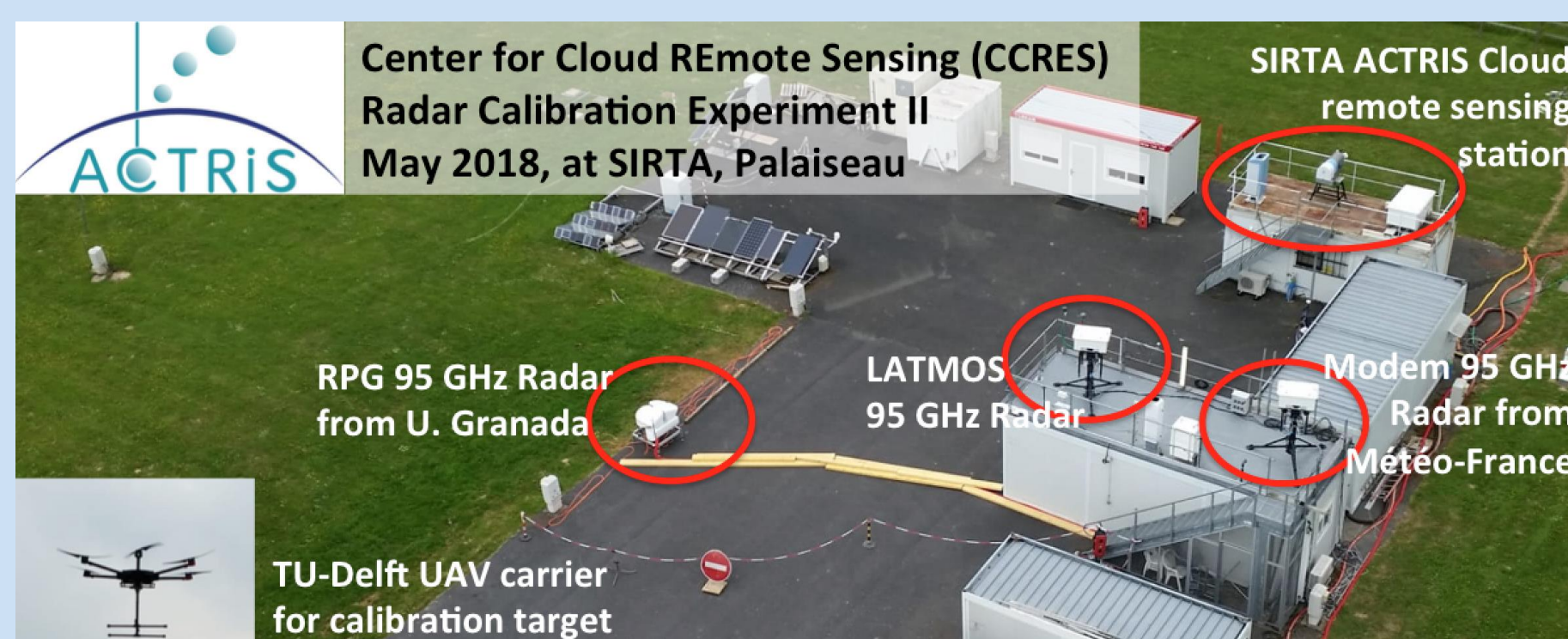
OBJECTIVES

- Frequency Modulated Continuous-Wave Doppler Cloud Radars (DCR) are instruments that improve our ability to study fog physical processes and have proven useful to support short-range prediction systems [1].
- Currently 15 DCRs are being installed at cloud monitoring stations that will provide data to ACTRIS (4 FMCW-DCRs and 11 DCRs).
- It is necessary to establish standard methodologies of calibration to ensure data intercomparability between the DCRs of the network.
- A DCR calibration campaign was organized by IPSL and performed at SIRTA [2] in Nov. 2017.
- Research for the future Center for Cloud Remote Sensing (CCRES), under development as part of ACTRIS-PPP.



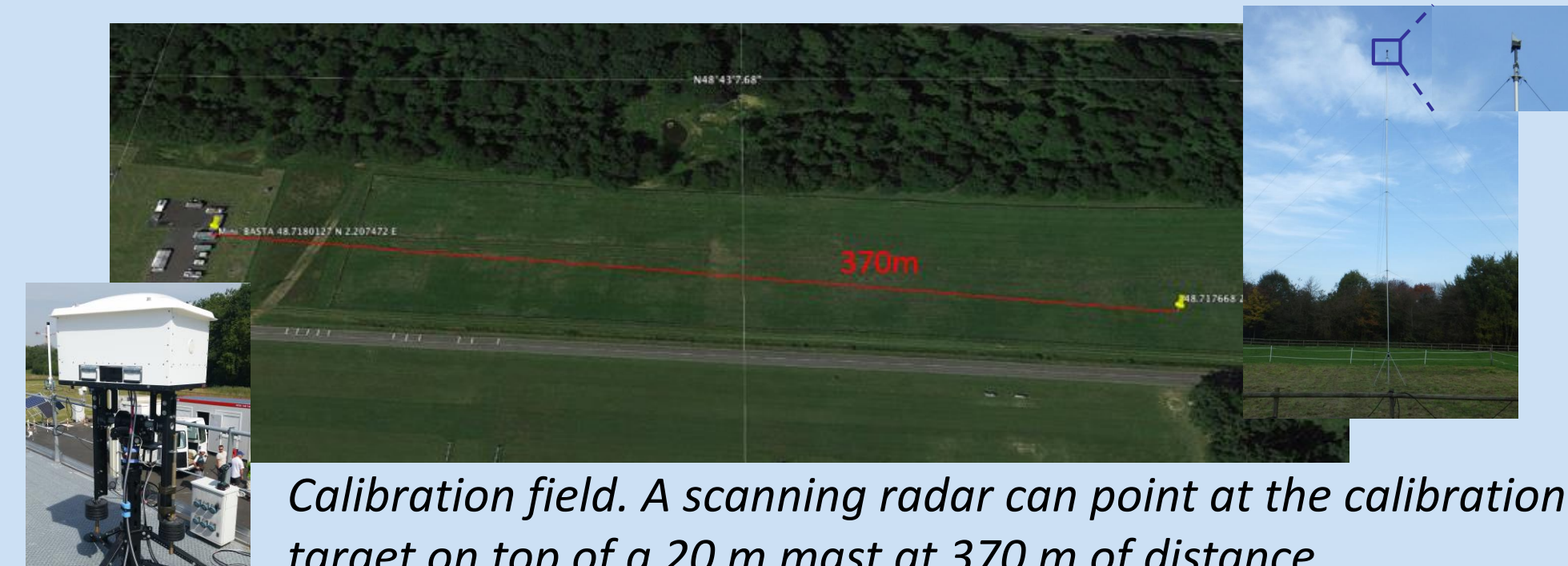
CCRES Calibration Experiment at SIRTA Observatory in May 2018

IN ADDITION TO STANDARD ATMOSPHERIC MONITORING, THERE IS AVAILABILITY OF SEVERAL CLOUD SENSING INSTRUMENTS, CHARACTERIZED RADAR TARGETS AND A RADAR CALIBRATION FIELD



Trihedral calibration targets. At a radio frequency of 95 GHz they have a peak RCS of 28.16 and 37.82 dB respectively.

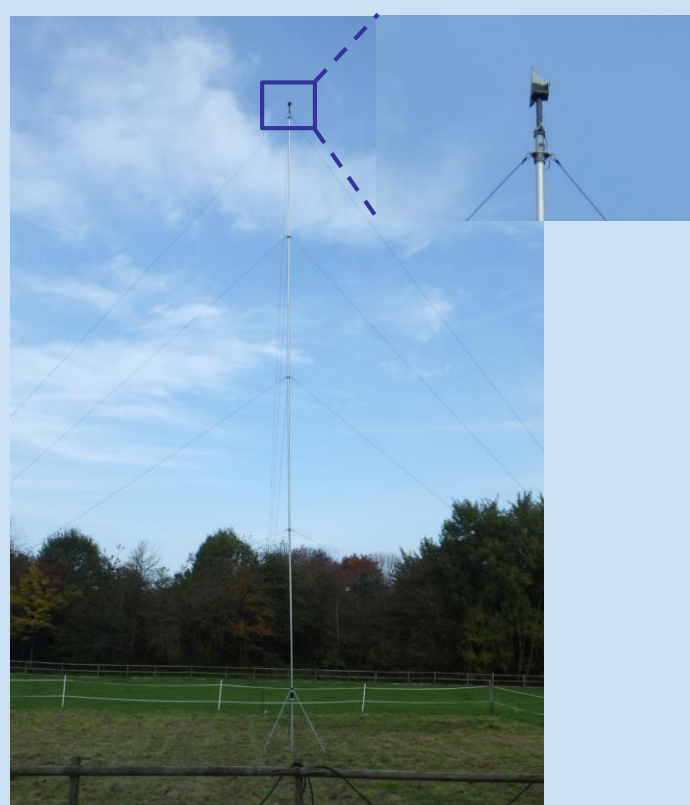
Remote sensing instruments	SIRTA ACTRIS Cloud remote sensing station (BASTA DCR, HATPRO MWR, CHM15K ceilometer) Météo-France mini-BASTA DCR LATMOS mini-BASTA DCR Granada RPG DCR
In-situ sensors	Degreane DF320 diffusometer LOAC granulometer DBS Spectro-pluviometer FM120 granulometer Standard meteorological station



Calibration field. A scanning radar can point at the calibration target on top of a 20 m mast at 370 m of distance.

Calibration Experiments

The design of a reliable calibration protocol requires the deployment of calibration experiments, to evaluate different methodologies and acquire instrumental and logistical experience.



Fixed target calibration

Study of the calibration constant stability with respect to environmental conditions using a characterized target fixed on top of a mast.

UAV assisted calibration

Retrieve the antenna gain pattern and the calibration constant using a characterized spherical target flown by an unmanned aerial vehicle (UAV). Method under development by the CCRES central facility of TU-Delft, Netherlands.



Calibration transfer

Transfer of the calibration constant from a mobile reference radar to another uncalibrated vertically pointing fixed radar.

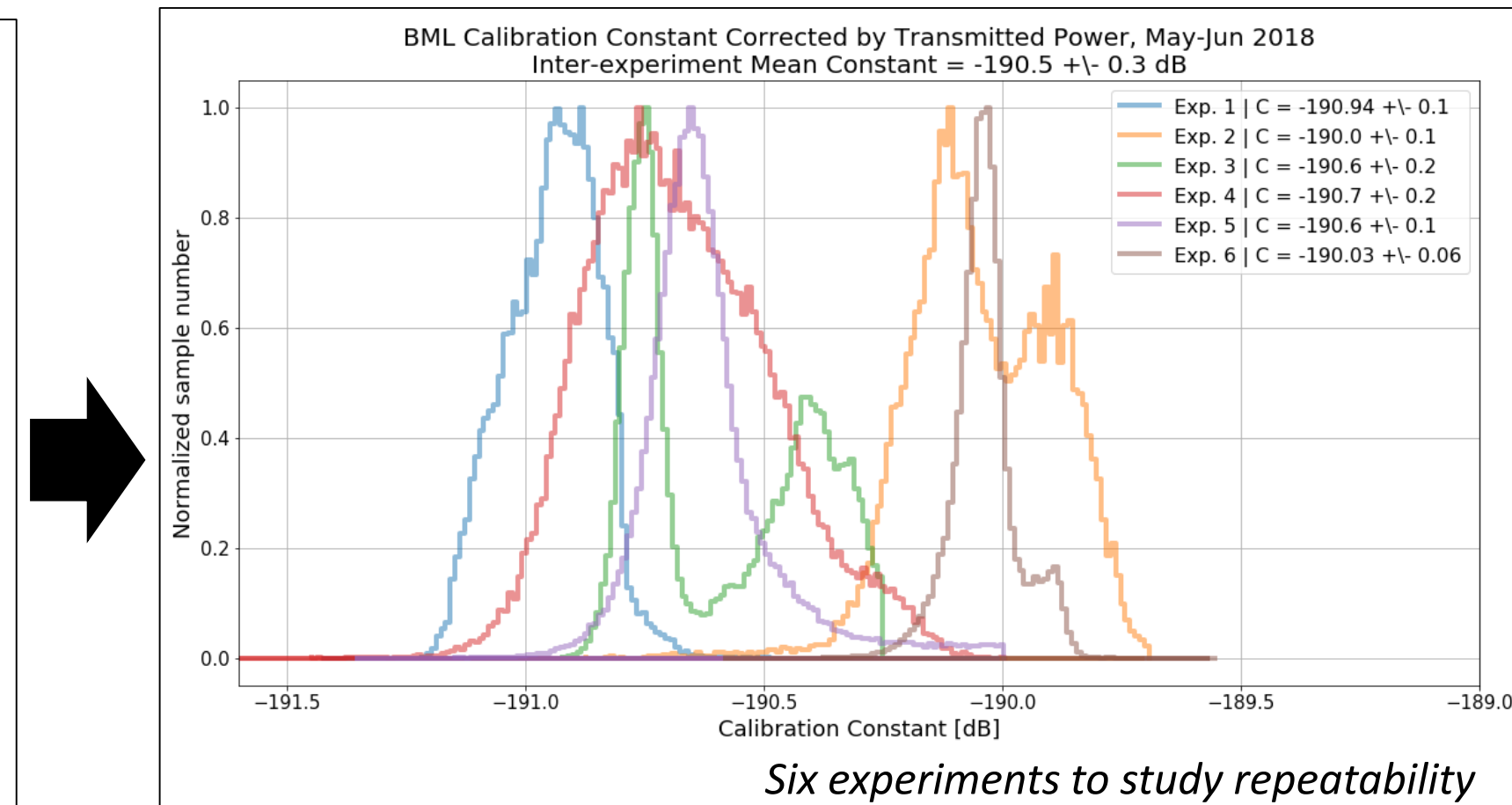
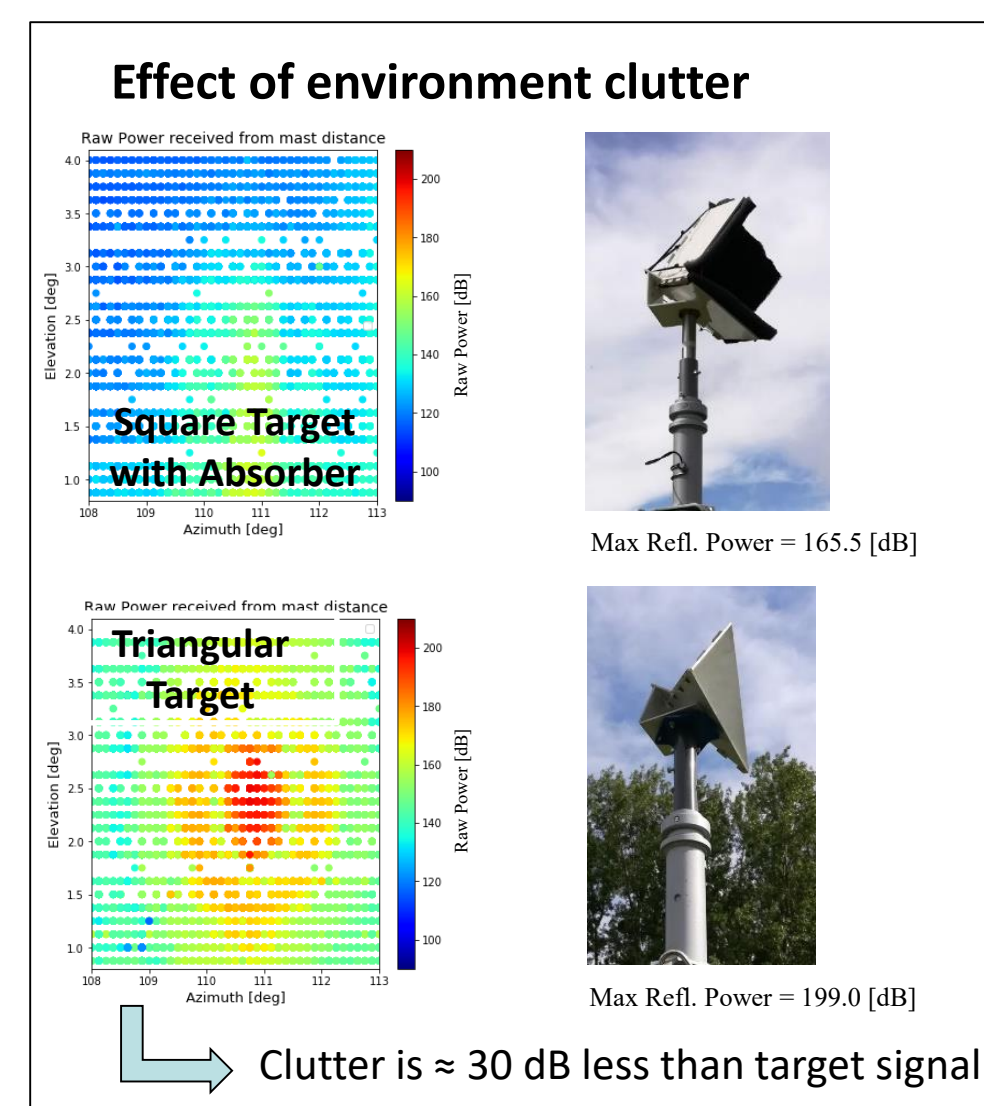
Radars used in the calibration transfer experiment: RPG (left) and reference BASTA-Mini (right).

Rain Calibration

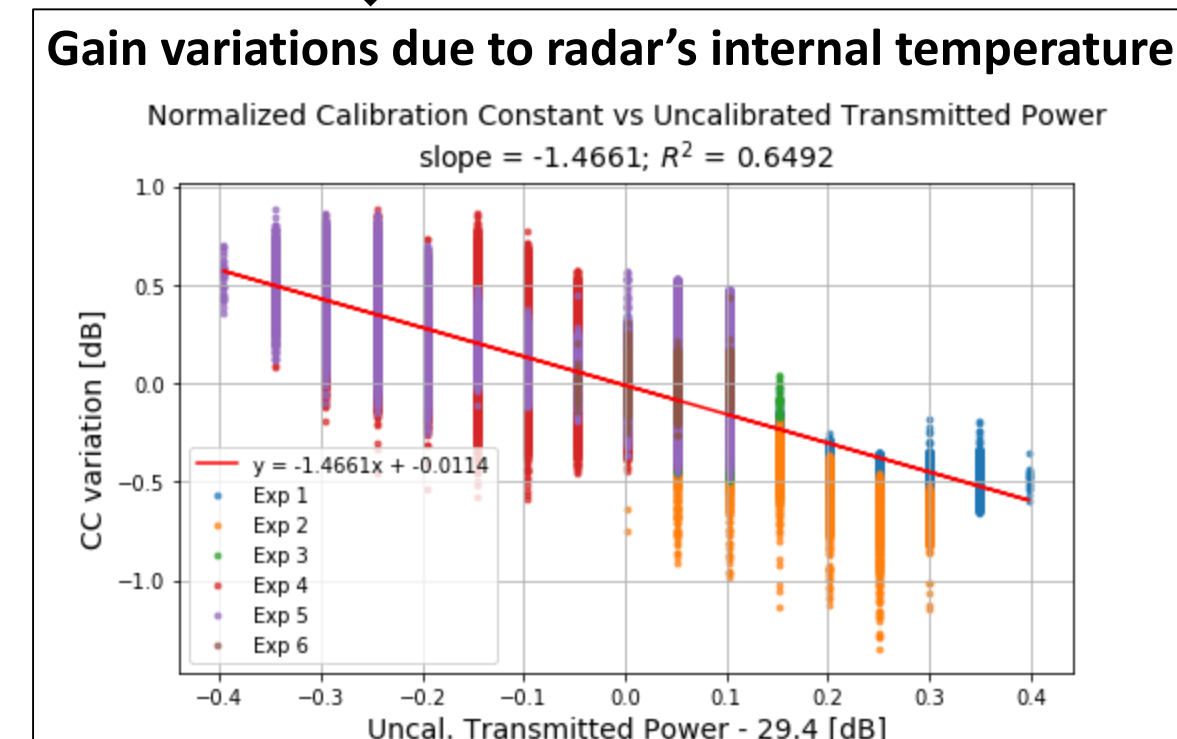
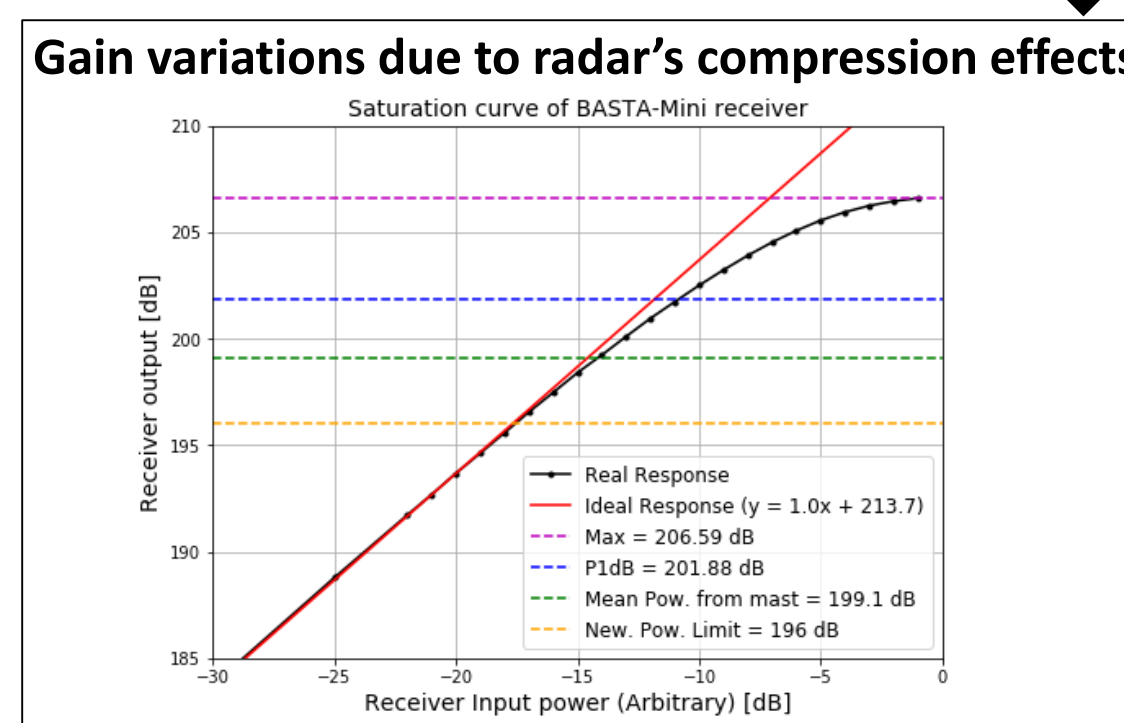
The radar uses precipitation with a known reflectivity as a characterized target [4]. Rain reflectivity is retrieved from the droplet size distribution of precipitation measured in-situ with an Spectropluviometer.



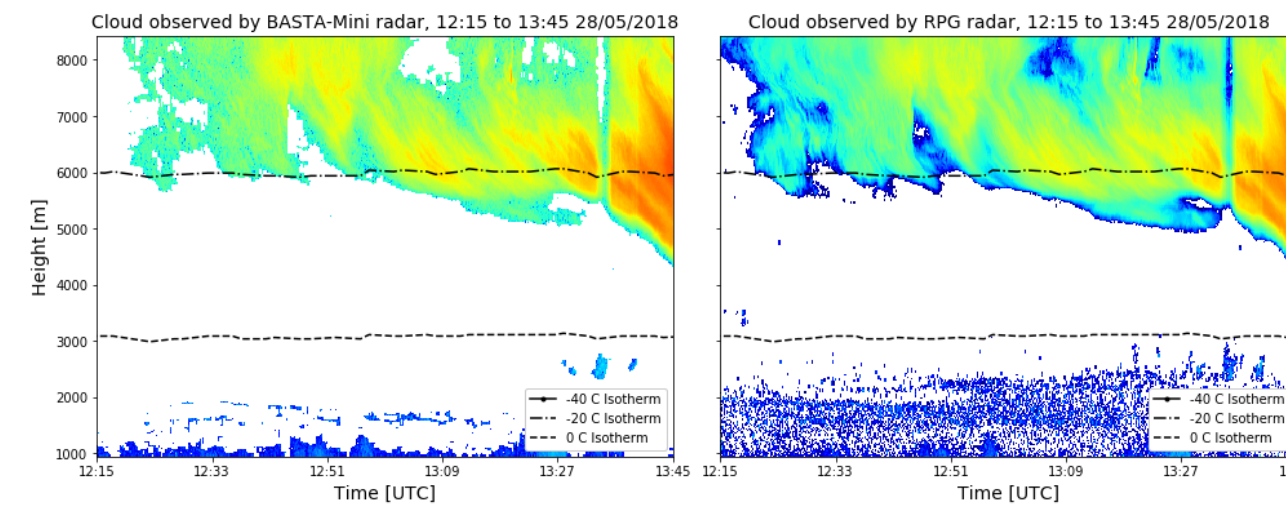
Current Results



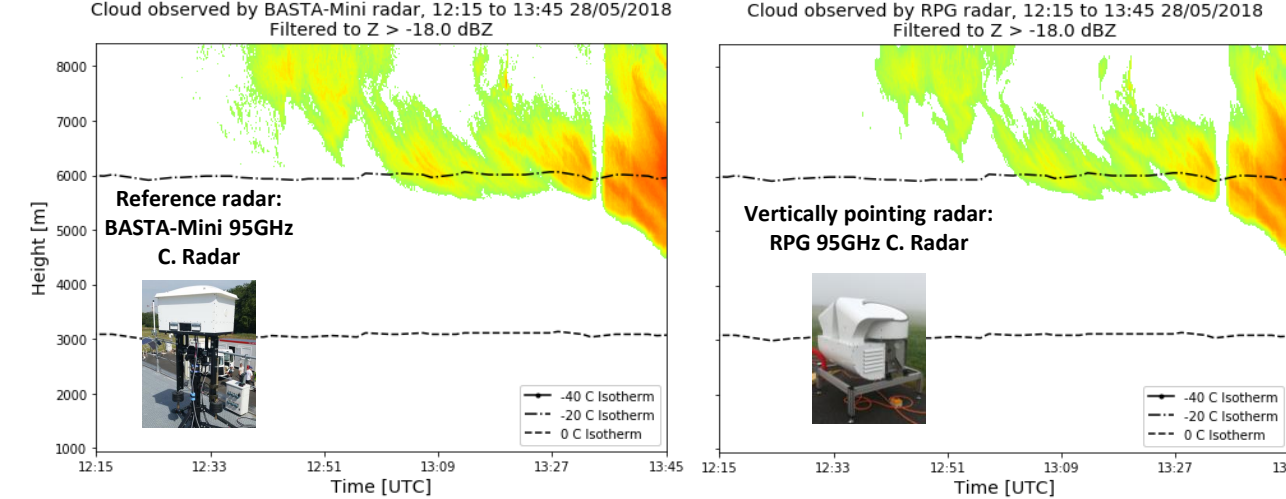
Calibration corrections



Single Cloud Event, BIAS calculated using all data

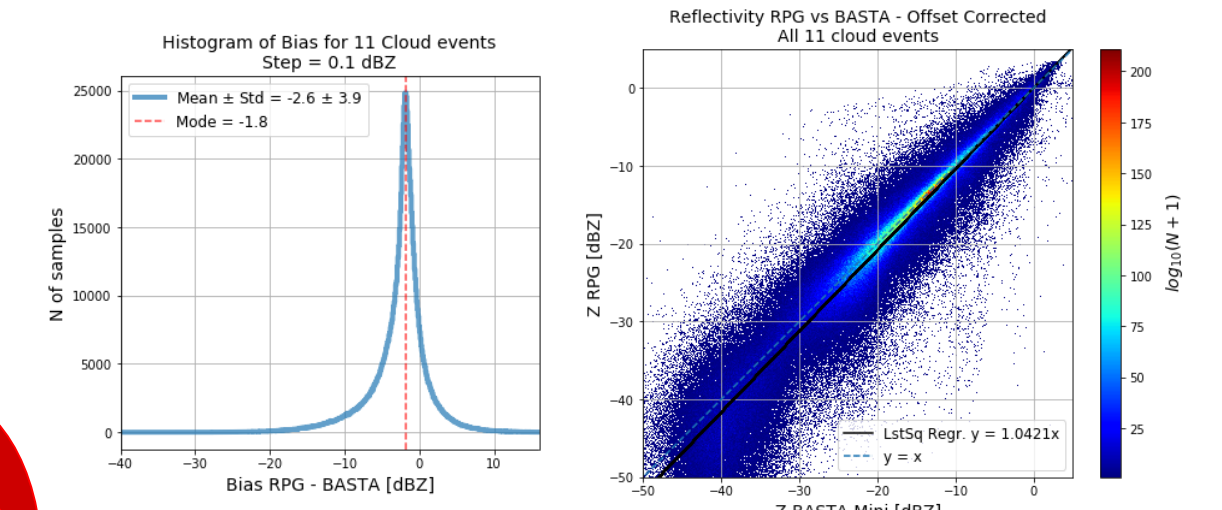


Single Cloud Event, BIAS calculated using reflectivity values above -18 dBZ only



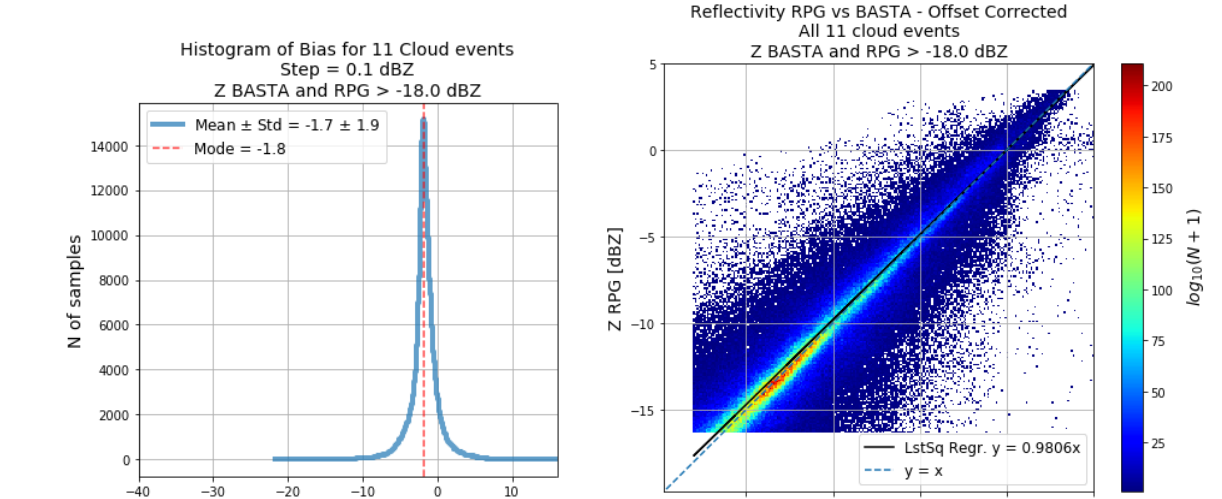
- Due to the similarities in the specifications, RPG data is interpolated to BASTA timeslice (3sec) and spacewise (25m).
- Both radars are pointed vertically to a 0.1° uncertainty, referenced at their external frames.
- Cloud events during or after rain removed to avoid wet radome effects.

Statistics using 11 cloud events between the 28 of May and 7 of June



All available data

Values above -18 dBZ only



Offset Correction = -1.7 dBZ (from average)

- [1] Wærsted, E. et al., P.: Radiation in fog: quantification of the impact on fog liquid water based on ground-based remote sensing, *Atmos. Chem. Phys.*, 17, 10811-10835, <https://doi.org/10.5194/acp-17-10811-2017>, 2017.
- [2] M. Haeffelin et al., "Sirta, a ground-based atmospheric observatory for cloud and aerosol research," *Annales Geophysicae*, vol. 23, no. 2, pp. 253-275, Feb. 2005. [Online]. Available: <https://hal.archives-ouvertes.fr/-hal-00329353>
- [3] Delanoe et al., BASTA: A 95-GHz FMCW Doppler Radar for Cloud and Fog Studies, *Journal of Atmospheric and Oceanic Technology*, American Meteorological Society, 33 (5), 1023-1038, doi:10.1175/JTECH-D-15-0104.1, 2016.
- [4] Hogan, R.J., et al. 2003: Absolute Calibration of 94/95-GHz Radars Using Rain. *J. Atmos. Oceanic Technol.*, 20, 572-580, [https://doi.org/10.1175/1520-0426\(2003\)20<572:ACOGRU>2.0.CO;2](https://doi.org/10.1175/1520-0426(2003)20<572:ACOGRU>2.0.CO;2)