The Bureau of Meteorology

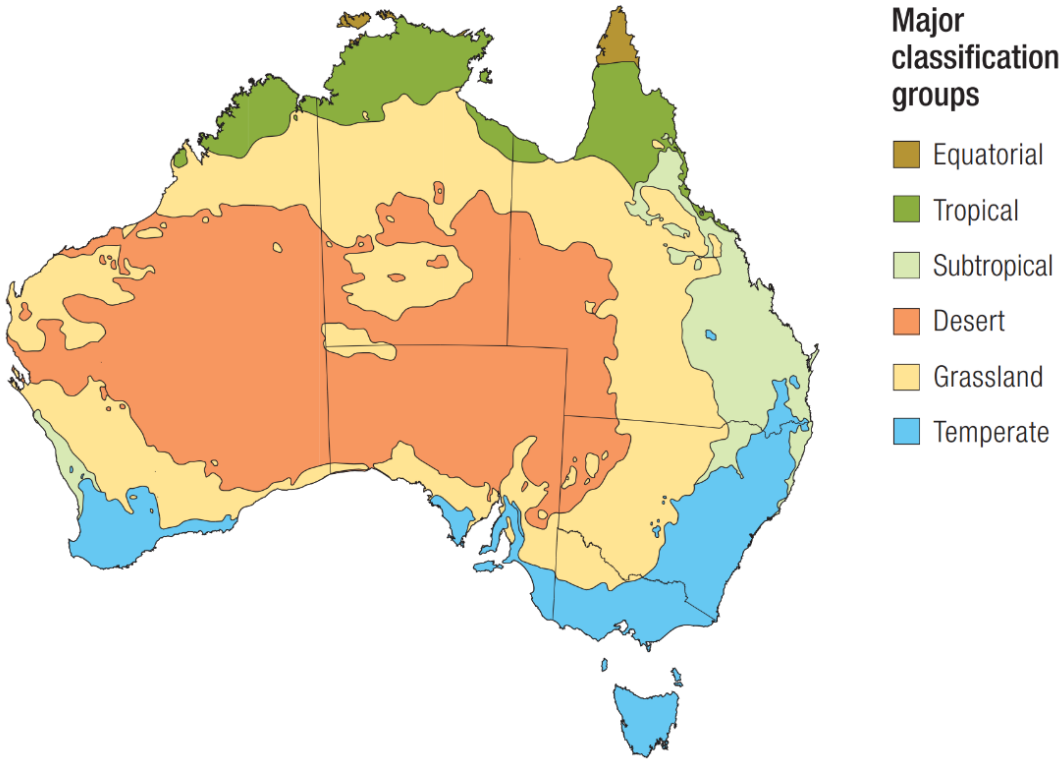
Real-time Monitoring and Calibration of Weather Radar Network using Multiple Techniques

Valentin Louf and Alain Protat

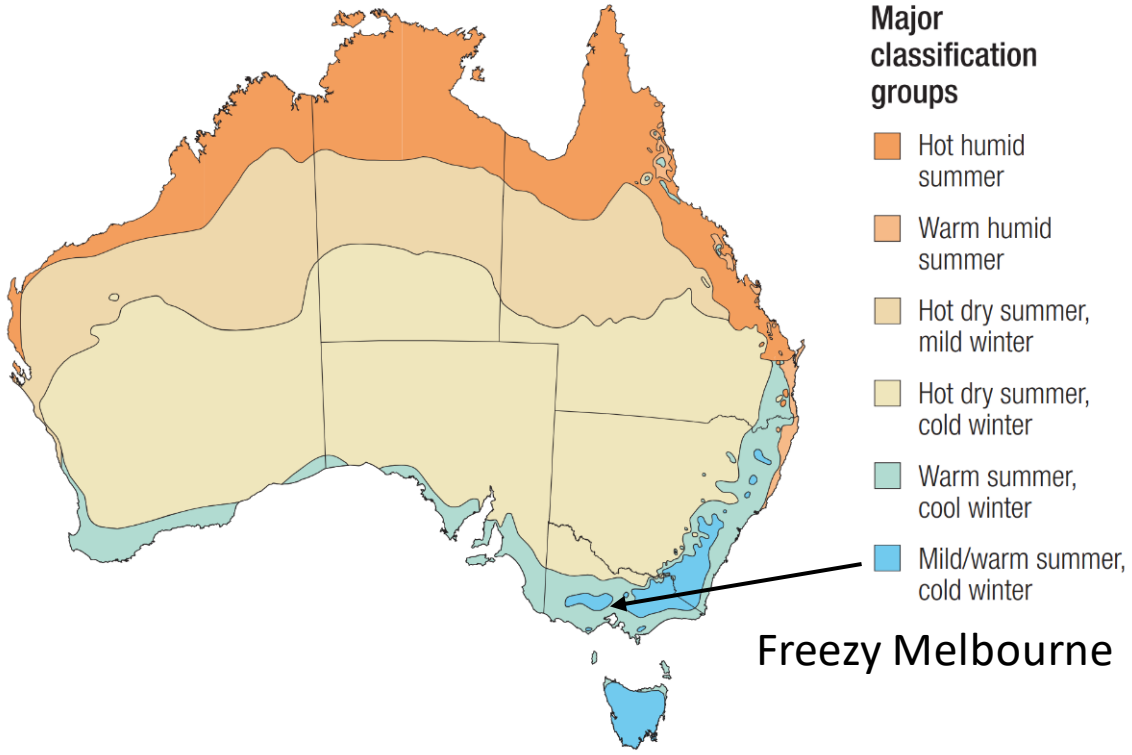
Australian Bureau of Meteorology

State of the Australian climate

Climate zones



Temperature and humidity

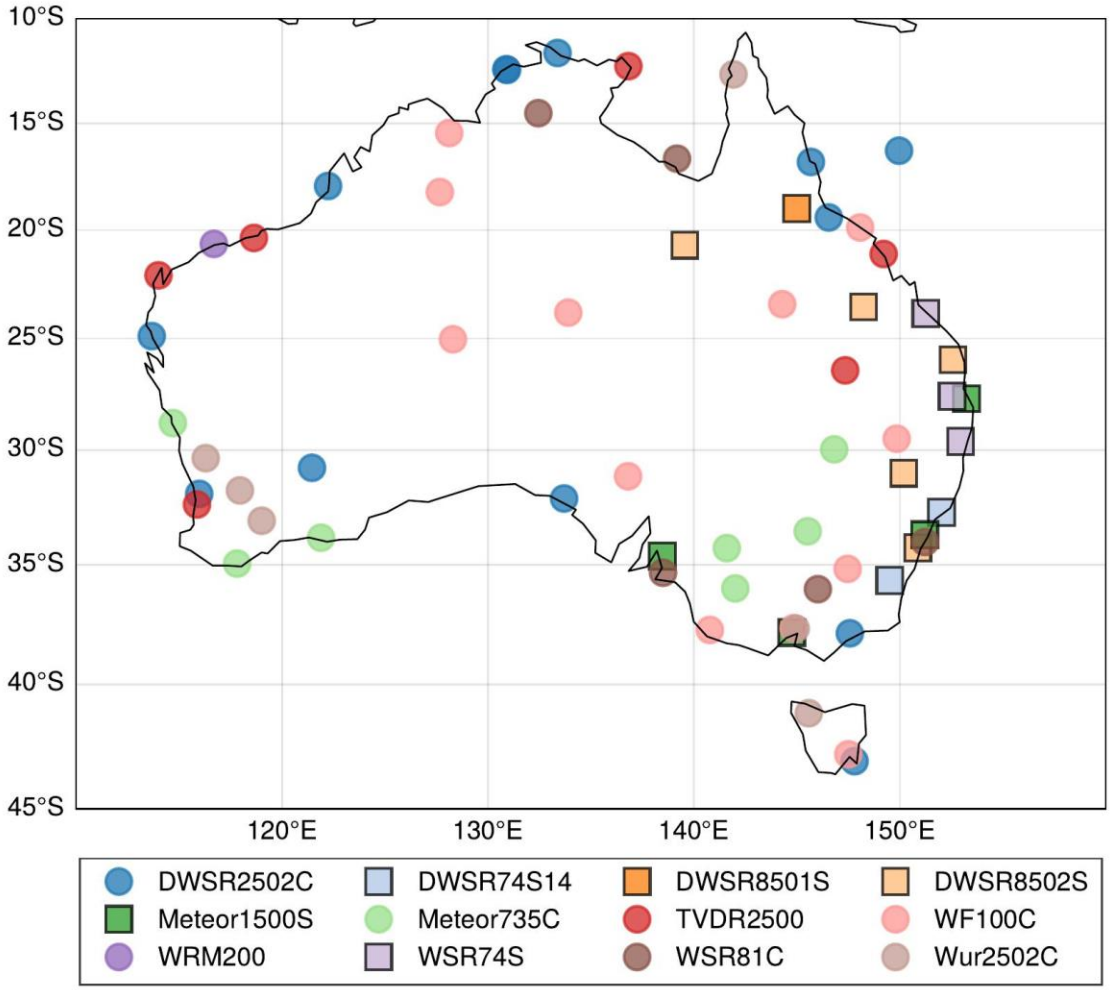


Freezy Melbourne

Heterogeneous climate and an heterogenous radar network

Figures from "Climate of Australia" by the Bureau of Meteorology

State of the Australian weather radar network.



- The Australian weather radar network:
  - **70** (and growing) radars.
  - **20 different types** (Manufacturers, beamwidth, bands, PRF, dual-pol, …)
  - S, C, and soon X-bands

Type	#	λ(cm)	Beam	Manu.	Band
DWSR 2502C	4	5.3	1.7 - 1.7	EEC/BOM	C
DWSR 74S-14	2	10.4	1.9	EEC/BOM	S
DWSR 8502S-14	5	10	1.9	EEC/BOM	S
Meteor 1500S	4	10	1	Leonardo	S (DP)
Meteor 1700S	3	10	1	Leonardo	S (DP)
Meteor 735C	9	5.3	1	Leonardo	C (DP)
TVDR 2500	6	5.3	1.0 - 1.9	EEC/BOM	C
WF 100-5C	3	5.3	1.7 - 2.0	EEC/BOM	C
WF 100-6C	10	5.3	1.0 - 1.7	EEC/BOM	C
WRM 200-14	1	5.3	1	Vaisala	C (DP)
WSR 74S	3	10	1.9	EEC/BOM	S
WSR 81C	3	5.3	1	EEC/BOM	C
Wurrung 2502C	16	5.3	1.7 - 1.7	EEC/BOM	C
MeteopressC-8	1	5.3	1.7	Meteopress	C (DP)

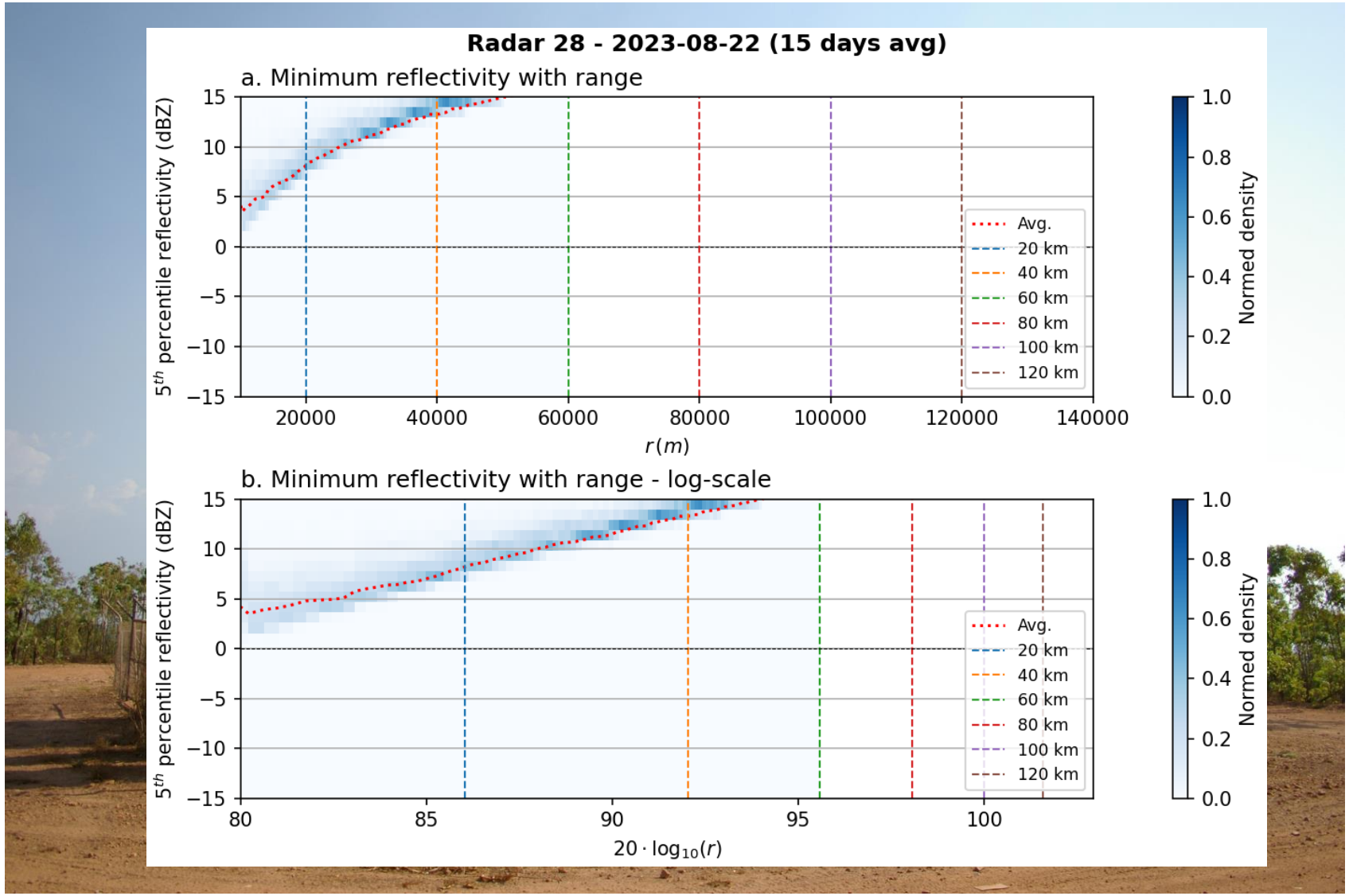
Notice to American taxpayers

If you've ever wondered where are the old American WSR-74…

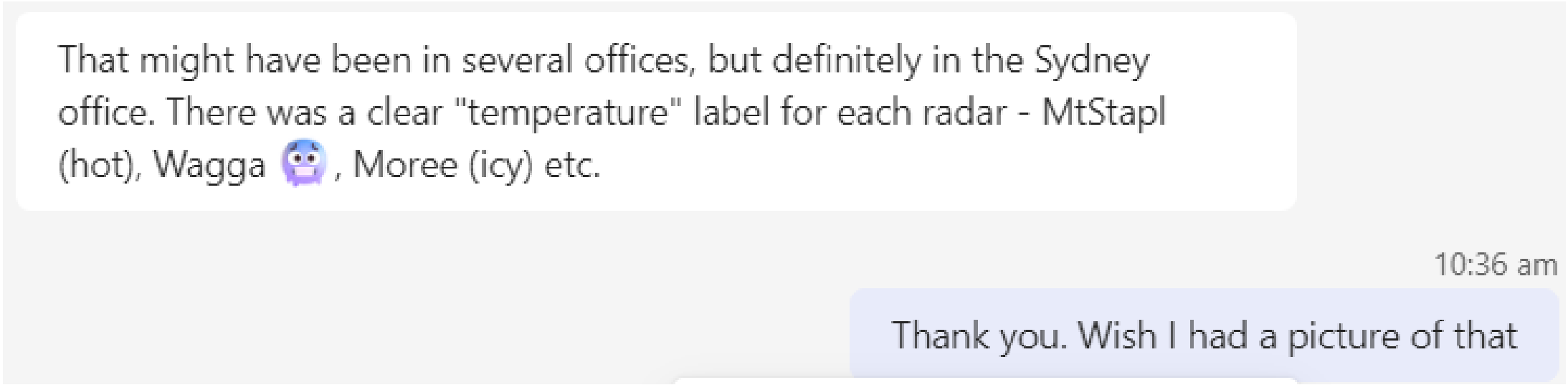
We've got them.

Off the scale sensitivity though!

(Berrimah, Darwin, NT)



How did we monitor the radar calibration?



- A post it board with our feelings about the radar

History of the project

An Integrated Approach to Weather Radar Calibration and Monitoring Using Ground Clutter and Satellite Comparisons

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(Manuscript received 17 January 2018, in final form 11 October 2018)

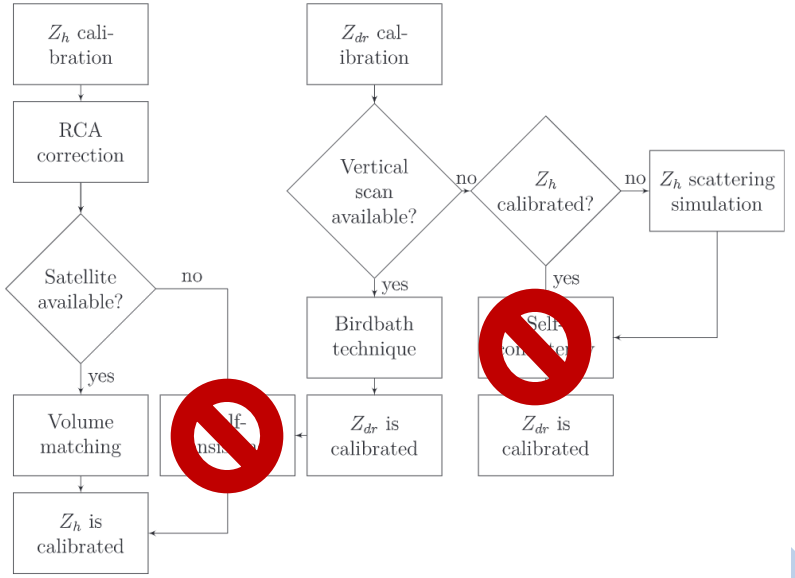


FIG. 19. Framework for adjusting the calibration of radar reflectivity and differential reflectivity.

Research → Operationalisation → Product

Integrated weather radar calibration techniques

GPM volume matching

- Reference for the entire network
- Absolute calibration
- A comparison every week
- ~ 2 dB accuracy

RCA (clutter)

- A point every 5 min
- Relative change only
- < 0.5 dB accuracy

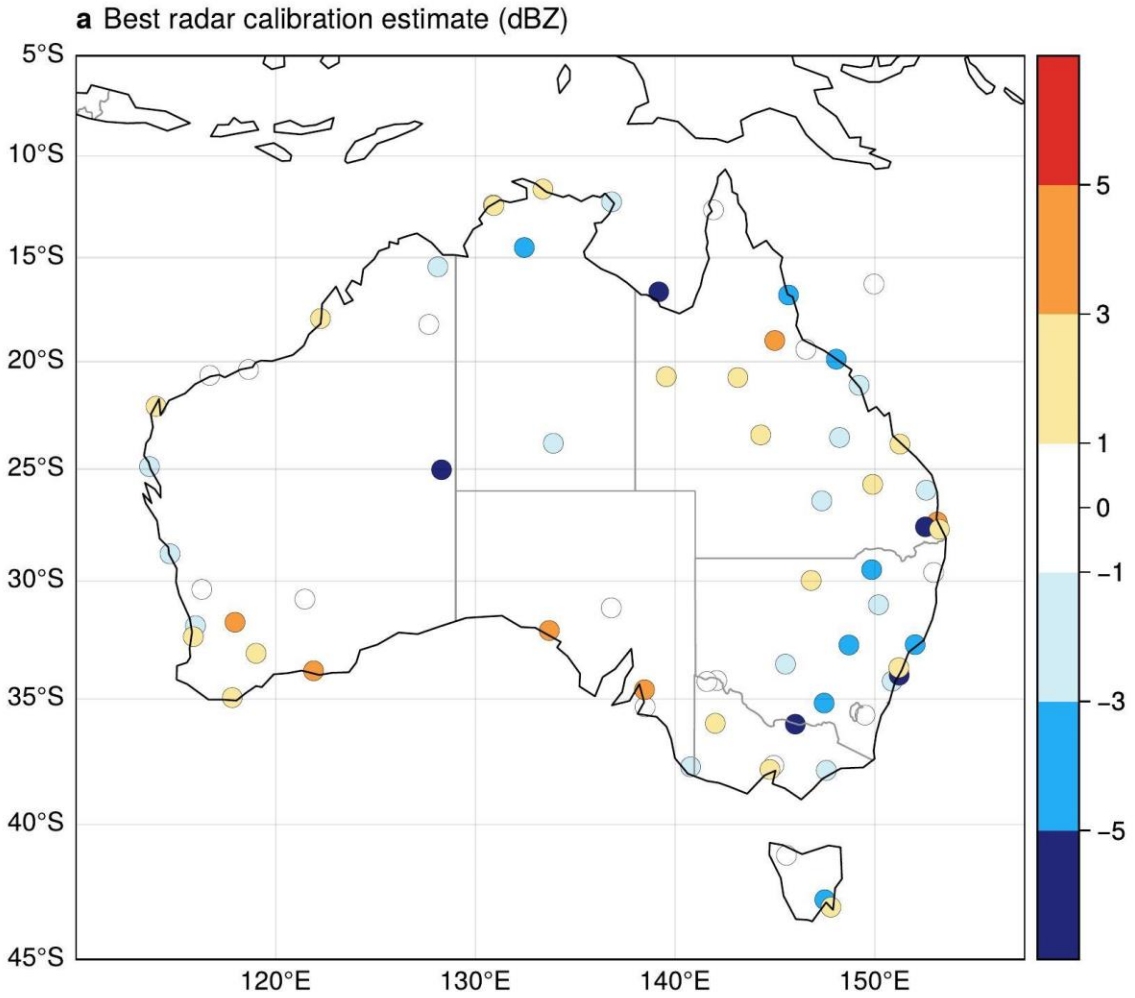
Solar (suncal)

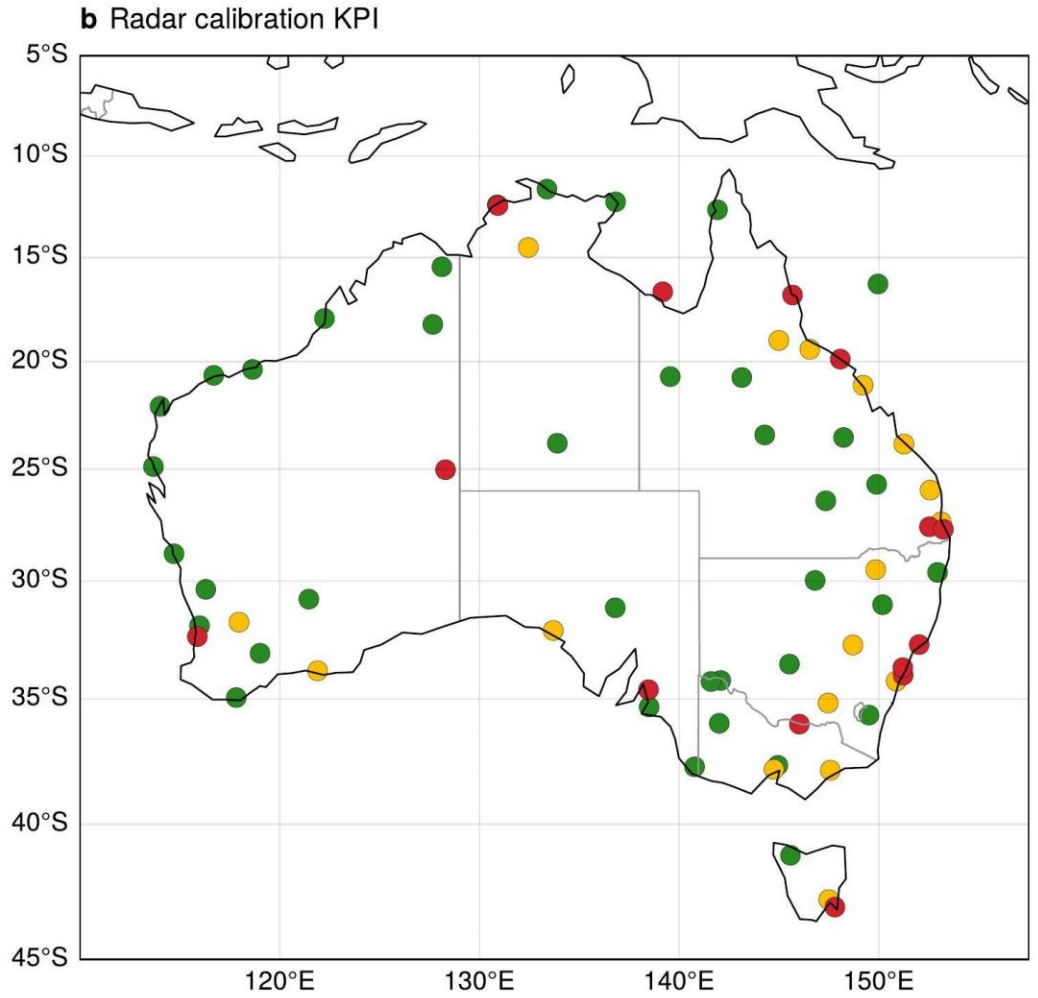
- Antenna pointing
- Points around sunrise and sunset
- 0.1 deg accuracy
- Info on the receiving channel

Integrated weather radar calibration techniques

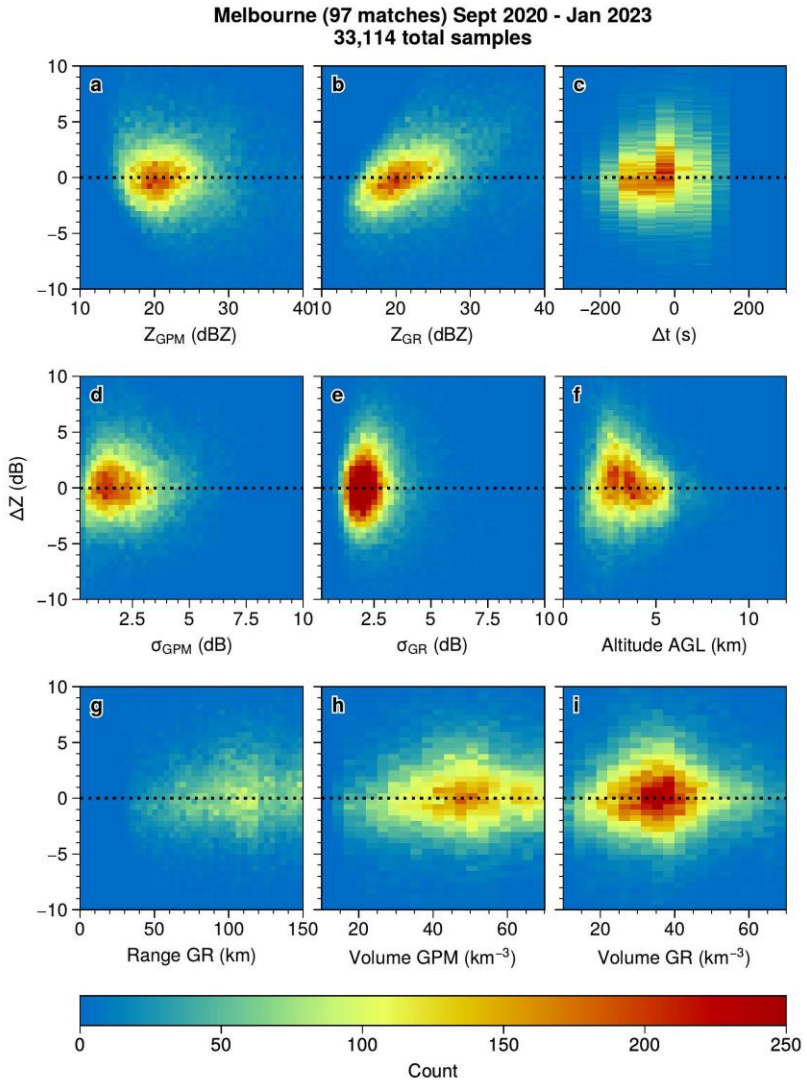
- Satellite (GPM) volume matching (Schwaller and Morris 2011, Warren et al. 2018)
- Monitoring of high reflectivity clutter echoes (Rinehart 1978, Silberstein et al. 2008)
- Solar interferences monitoring (Whiton et al. 1976, Huuskonen and Holleman 2007, Altube et al. 2016)
- Range sensitivity monitoring
- ZDR calibration monitoring (Gorgucci 1992, Richardson 2017, Katsumata 2023)
- Dual-polarisation moments monitoring (Marks et al. 2011)
- T/R limiter monitoring
- Time monitoring

S3CAR results





GPM Volume matching technique



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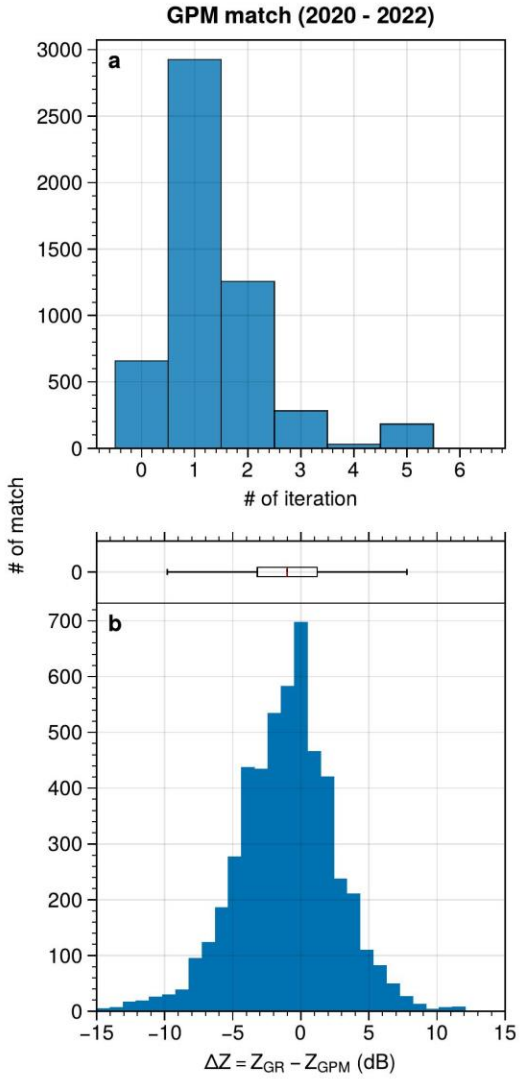
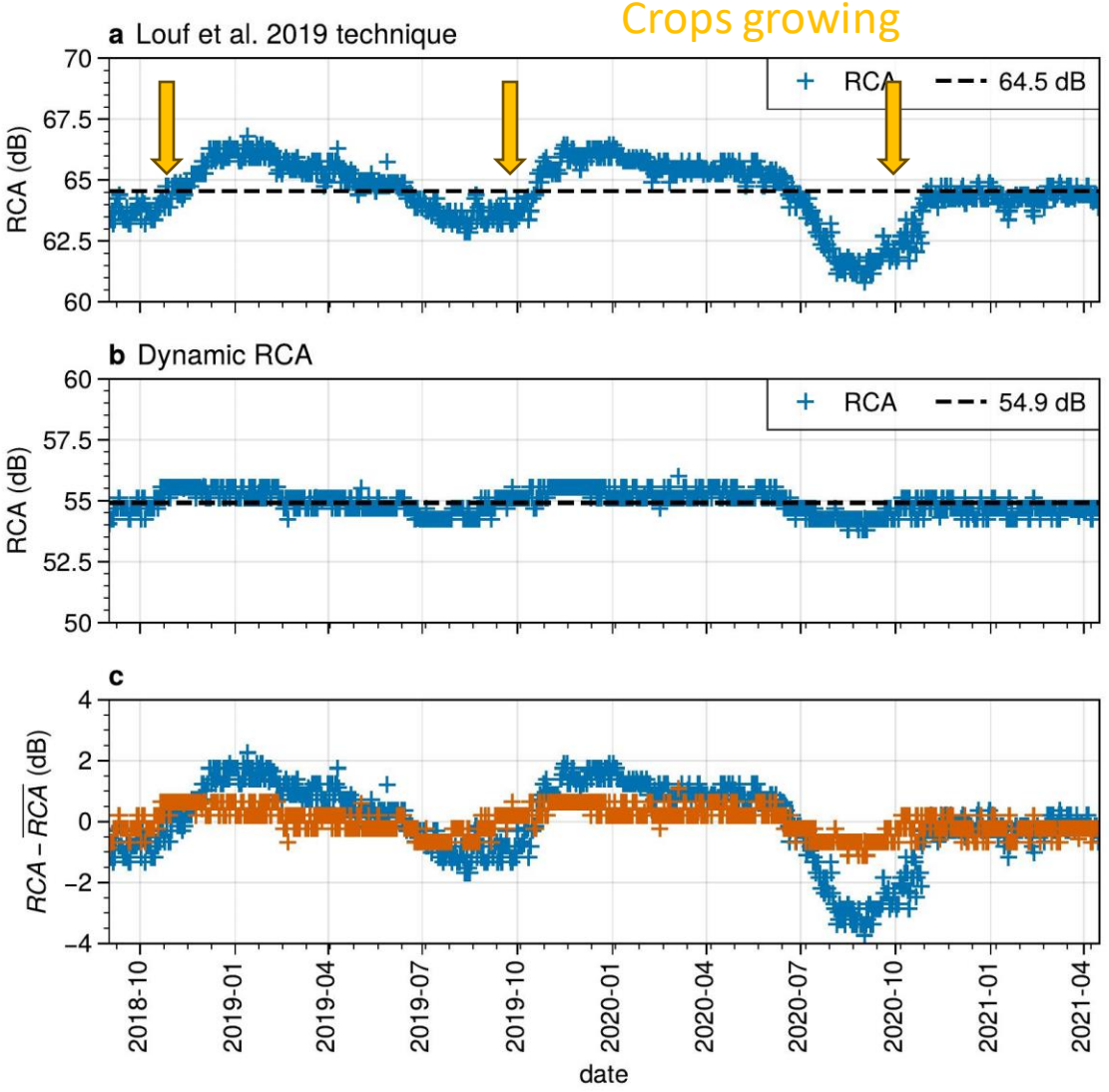
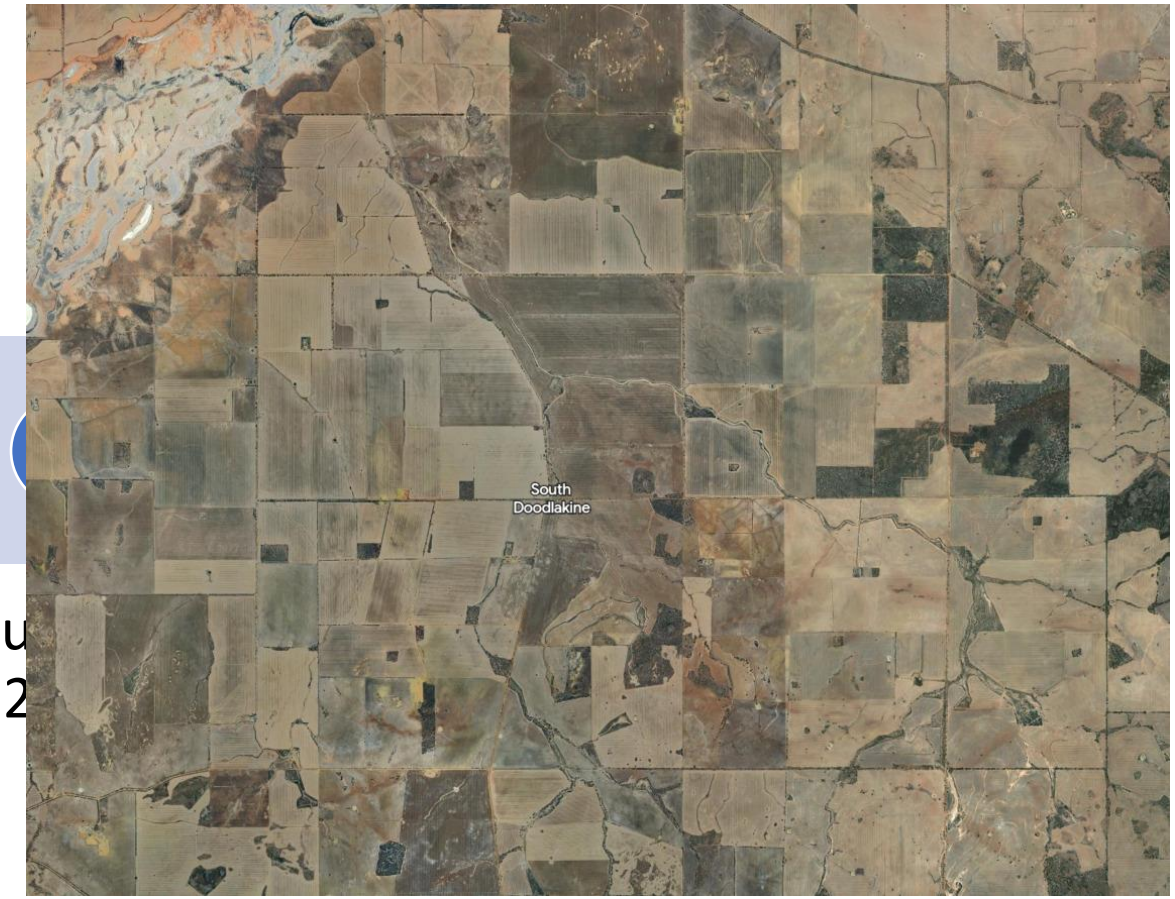


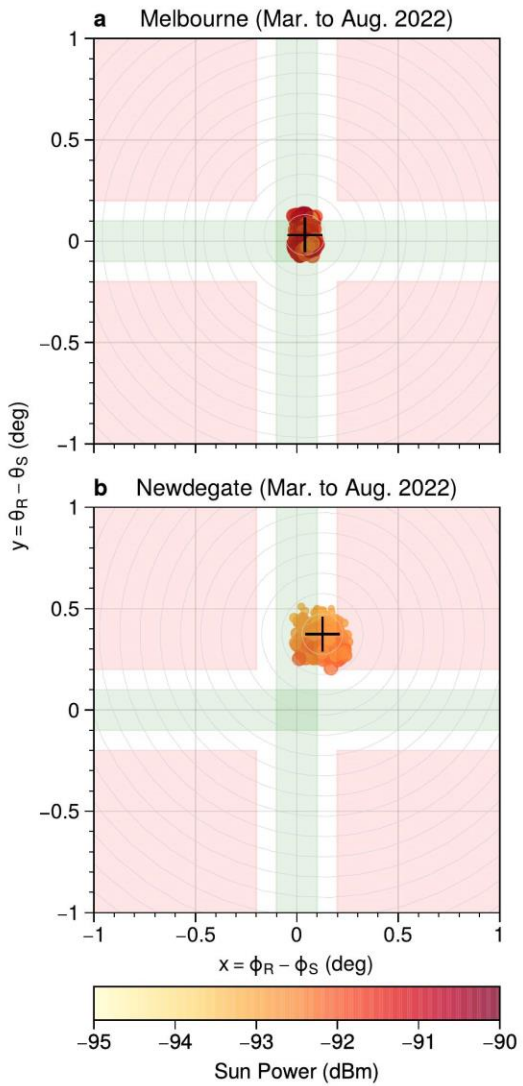
Clutter monitoring: dynamic extended RCA

Crops growing





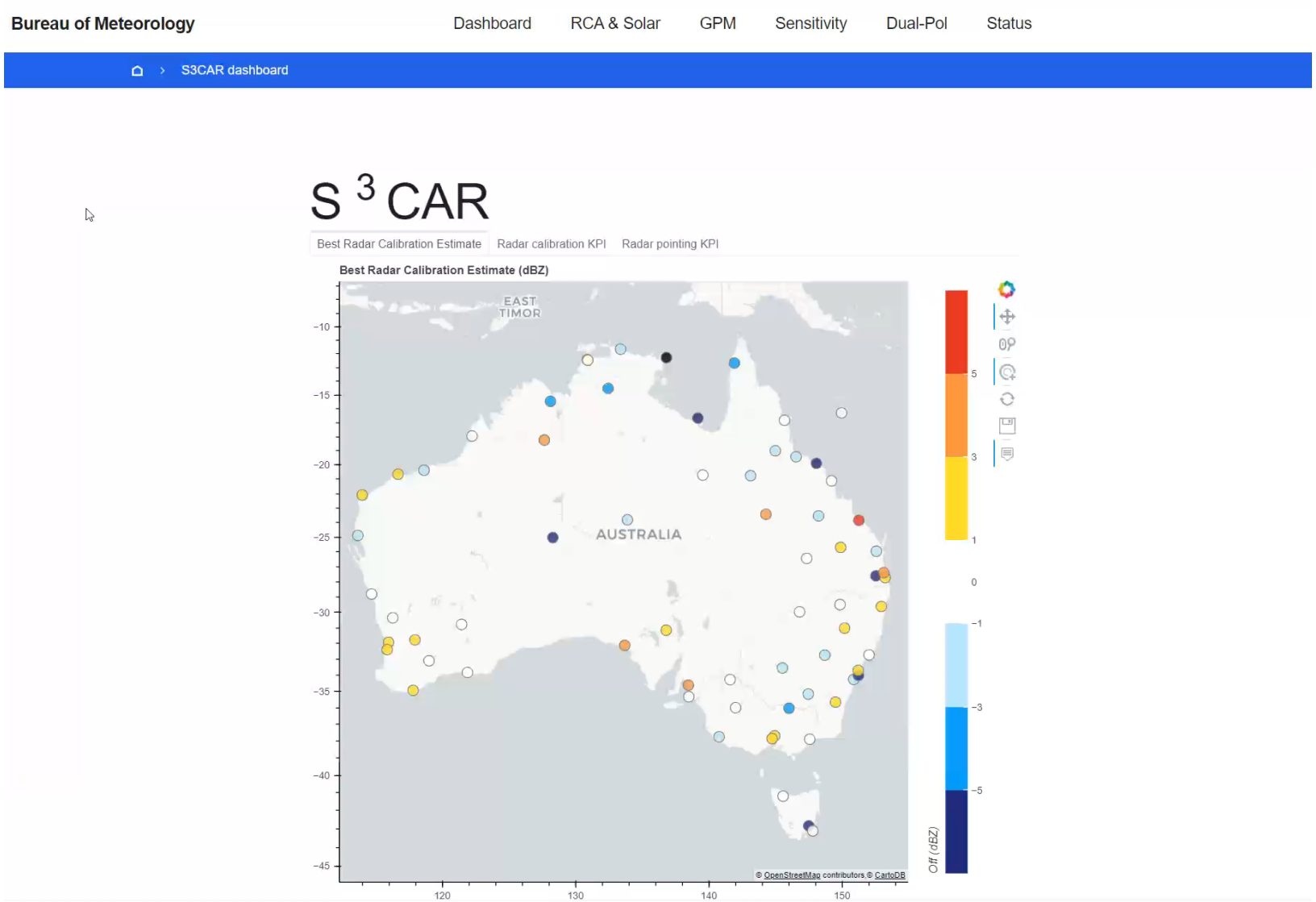
Solar calibration



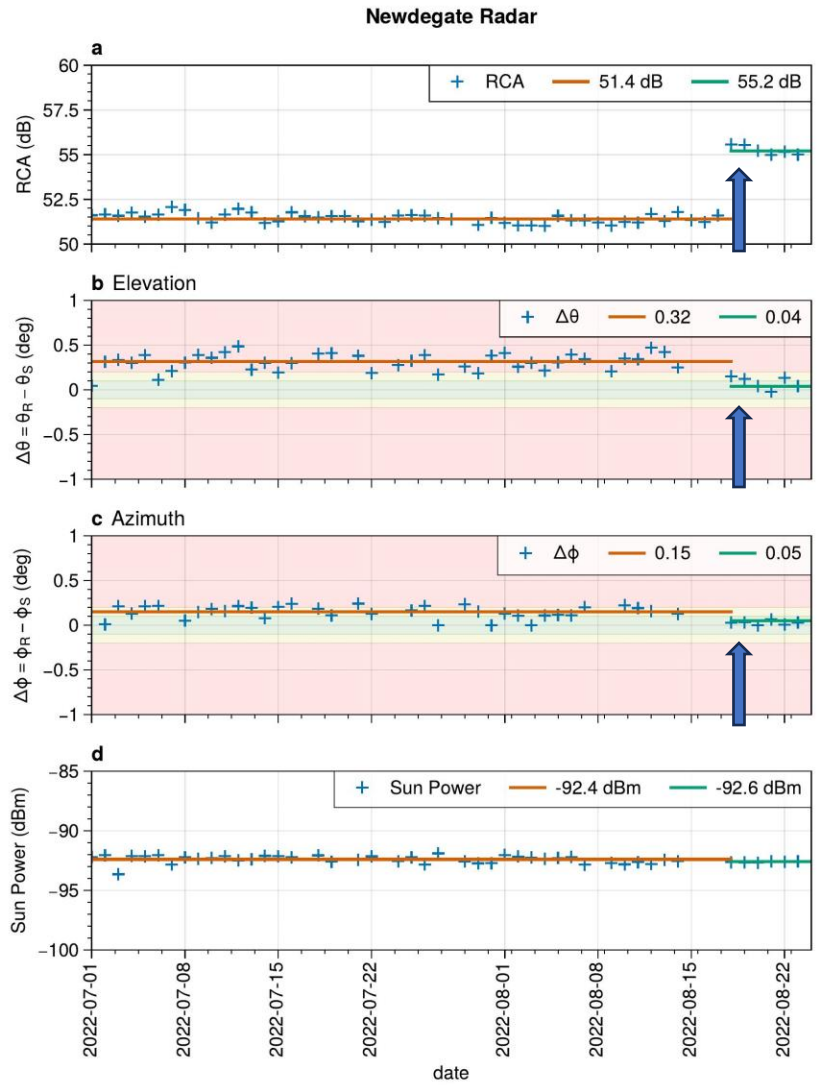
Based on:

- Huuskonen, A., & Holleman, I. (2007). Determining Weather Radar Antenna Pointing Using Signals Detected from the Sun at Low Antenna Elevations. *Journal of Atmospheric and Oceanic Technology*, *24*(3), 476–483. https://doi.org/10.1175/JTECH1978.1
- Holleman, I., & Huuskonen, A. (2013). Analytical formulas for refraction of radiowaves from exoatmospheric sources. *Radio Science*, *48*(3), 226–231. https://doi.org/10.1002/rds.20030
- Gabella, M., Sartori, M., Boscacci, M., & Germann, U. (2014). Vertical and Horizontal Polarization Observations of Slowly Varying Solar Emissions from Operational Swiss Weather Radars. *Atmosphere*, *6*(1), 50–59. https://doi.org/10.3390/atmos6010050
- Altube, P., Bech, J., Argemí, O., & Rigo, T. (2015). Quality control of antenna alignment and receiver calibration using the sun: Adaptation to midrange weather radar observations at low elevation angles. *Journal of Atmospheric and Oceanic Technology*. https://doi.org/10.1175/jtech-d-14-00116.1
- Huuskonen, A., Kurri, M., & Holleman, I. (2016). Improved analysis of solar signals for differential reflectivity monitoring. *Atmospheric Measurement Techniques*, *9*(7), 3183–3192. https://doi.org/10.5194/amt-9-3183-2016

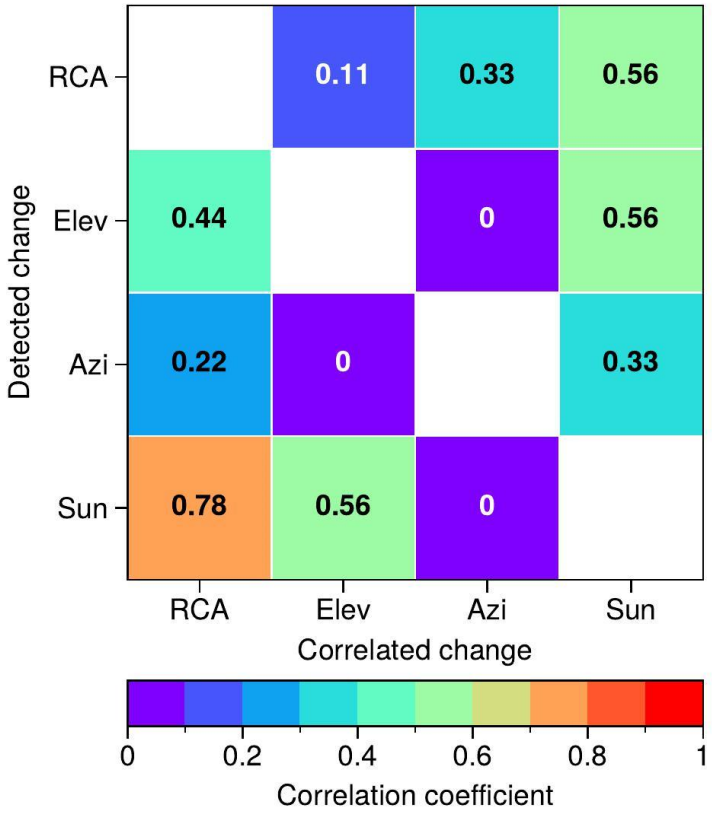
S3CAR website



Evaluating the integrated diagnostics



- A change in GPM volume matching correlates at p=0.84 to a change in the RCA



Publications

Individual techniques are freely available on GitHub (Apache 2 licence):

Github.com/vlouf/suncal

Github.com/vlouf/cluttercal

Github.com/vlouf/gpmmatch

SUCCESS stories:

- Quarterly meeting with the radar engineering team
- "time monitoring" requested by the CEO

Real-Time Monitoring of Weather Radar Network Calibration and Antenna Pointing

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ABSTRACT: We present an integrated framework that leverages multiple weather radar calibration and monitoring techniques to provide real-time diagnostics on reflectivity calibration, antenna pointing, and dual-polarization moments. This framework uses a volume-matching technique to track the absolute calibration of radar reflectivity with respect to the Global Precipitation Measurement (GPM) spaceborne radar, the relative calibration adjustment (RCA) technique to track relative changes in the radar calibration constant, the solar calibration technique to track daily change in solar power and antenna pointing error, and techniques that track properties of light-rain medium to monitor the differential reflectivity and dual-polarization moments. This framework allows for an evaluation of various calibration and monitoring techniques. For example, we found that a change in the RCA is highly correlated to a change in absolute calibration, with respect to GPM, if a change in antenna pointing can first be ruled out. It is currently monitoring 67+ radars from the Australian radar network. Because of the diverse and evolving nature of the Australian radar network, flexibility and modularity are at the core of the calibration framework. The framework can tailor its diagnostics to the specific characteristics of a radar (band, beamwidth, etc.). Because of its modularity, it can be expanded with new techniques to provide additional diagnostics (e.g., monitoring of radar sensitivity). The results are presented in an interactive dashboard at different level of details for a wide and diverse audience (radar engineers, researchers, forecasters, and management), and it is operational at the Australian Bureau of Meteorology.

Available in AMS Journal of Atmospheric and Oceanic Technologies Issue 7

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SCAR: Satellite Clutter Absolute Radar calibration