

Surface- and Satellite-Based Methods for Calibrating 915-MHz Wind Profilers

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for more details, see

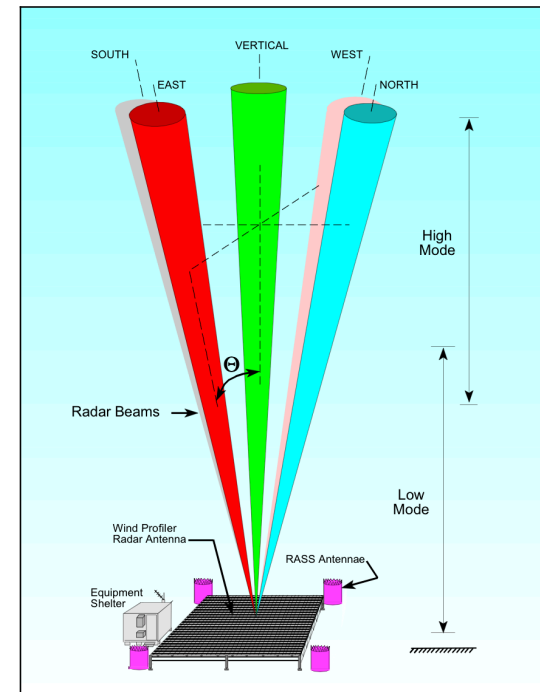
Hartten, L. M., P. E. Johnston, V. M. Rodríguez Castro, and P. S. Esteban Pérez, 2019: Post-deployment calibration of a tropical UHF profiling radar via surface- and satellite-based methods. *J. Atmos. Oceanic Tech.*, accepted pending minor revision.

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Wind Profiling Radars

- **Typical characteristics**

- Bragg scatter off small variations in the index of refraction
- Rayleigh scatter off hydrometeors (esp. 400-500, 900-1400 MHz)
- Returns sampled at equally spaced times (“range gating”)
- Calibrated for wind but not reflectivity

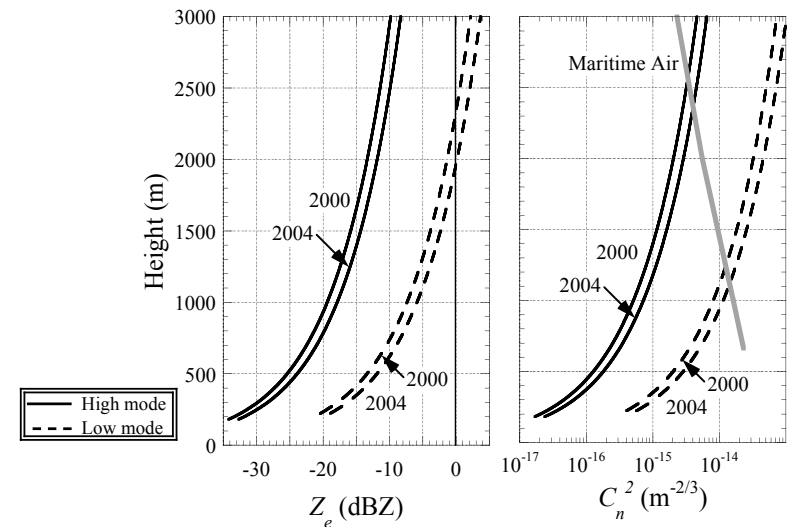


(schematic from *U.S. Wind Profilers: A Review*, FCM-R14-1998)

- **Why calibrate?**

More information about atmosphere!

- Equivalent reflectivity Z_e
- Structure function parameter C_n^2
- Compare with other radars



(figure adapted from *Hartten and Johnston (2014, J. Appl. Meteor. Clim.)*)

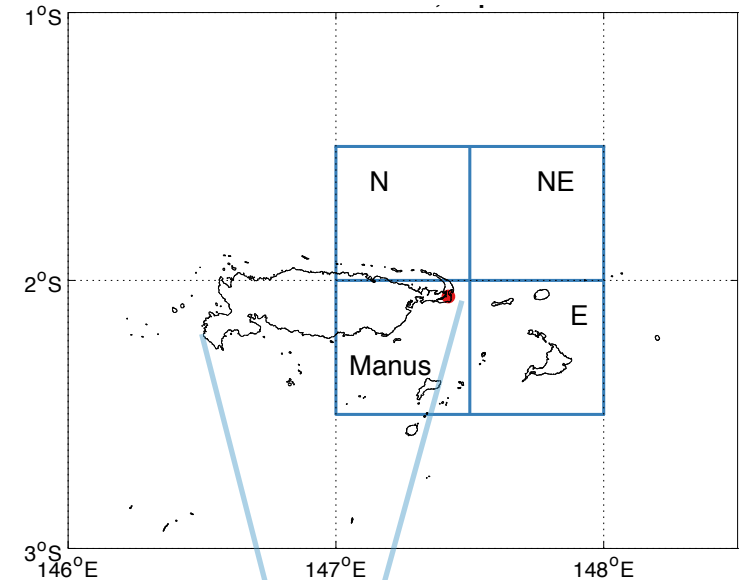
Manus, Papua New Guinea

- **Profiler (deployed 1992 – 2001)**

- November 1992 – February 1993
&
July 1992 – August 1994
- Vertical beam, 105 m spacing to 5.2 km
- dwell = 38 seconds, repeat = 3.8 minutes
- Collocated tipping-bucket rainfall

- **TRMM (deployed 1997 – 2015)**

- Calibrated K_u band radar (13.8 GHz)
- January 1998 – July 2001
- 4.3 km footprint, 250 m vertical resolution
- Monthly means, 0.5° grid



Calibrating against Surface Rainfall

- **Match profiler estimate with tipping bucket measurement**

- Over many hours of stratiform rain
- 1 November 1992 - 28 February 1993

- **Case Selection**

- Daily rainfall $\geq 10\text{mm}$ and profiler-detected precip $\geq 5\text{h} \Rightarrow 10$ possible cases
- Character of reflectivity and bright band $\Rightarrow 2$ primary cases
2 secondary cases for verification

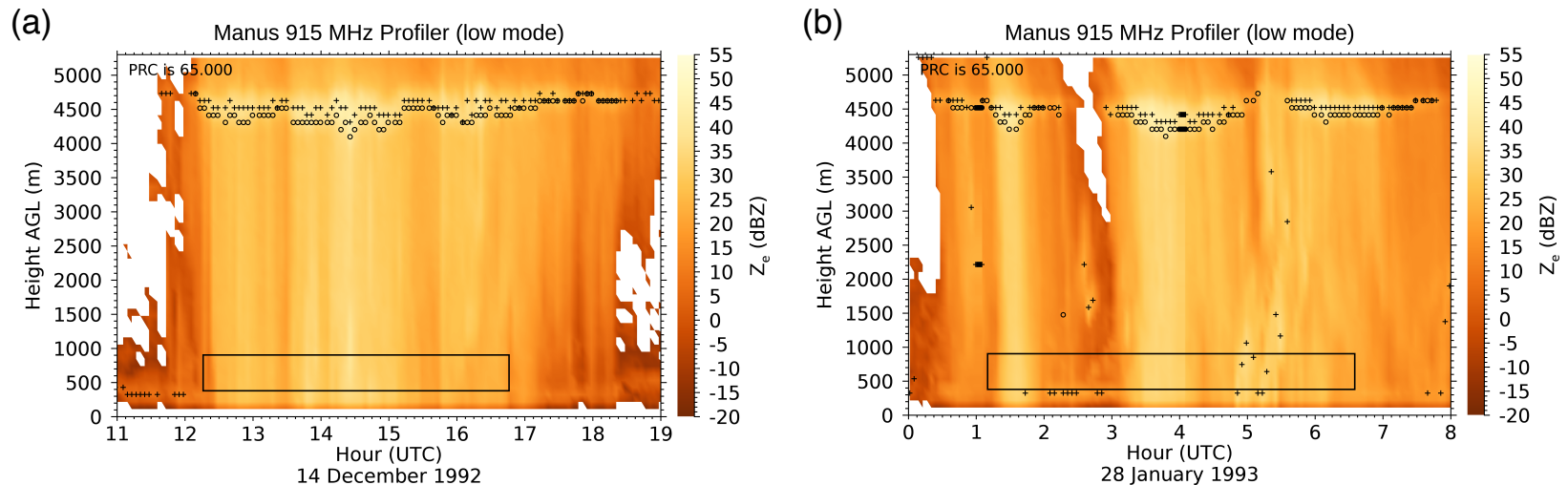
- **Z – R Relationship**

- Employ $Z = f(R, D)$ and appropriate assumed drop-size distribution
where Z is reflectivity (dBZ), R is rain rate (mm/h), D is drop diameter (mm)
- For stratiform rain, used the common $Z = 200R^{1.6}$ (*Marshall et al. (1955), Adv. Geophys.*)

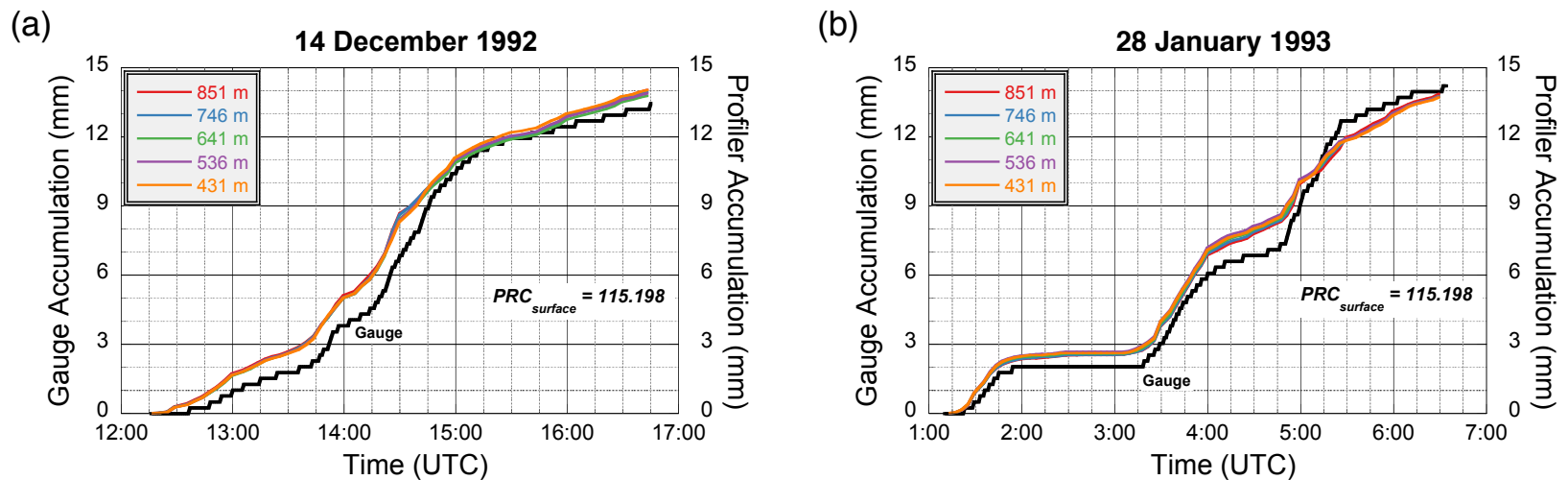
- **Iterate to a final Profiler Radar Constant (PRC)**

Calibrating against Surface Rainfall (cont'd)

- Initial (poorly calibrated) reflectivity during primary cases



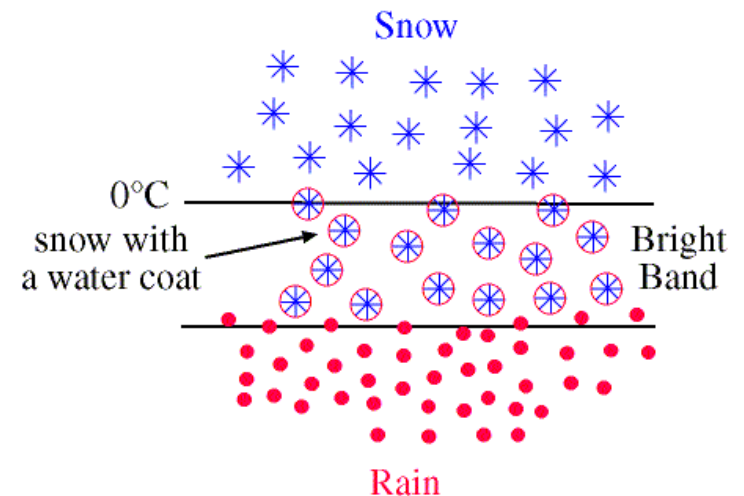
- Estimated rainfall for final surface-based calibration ($\pm 4\%$ of gauge)



Calibrating against Satellite Reflectivity

- **Match profiler reflectivity to TRMM reflectivity**
 - Use longterm averages to compensate for temporal and spatial mismatches

- **Take advantage of the “bright band” associated with stratiform rain**

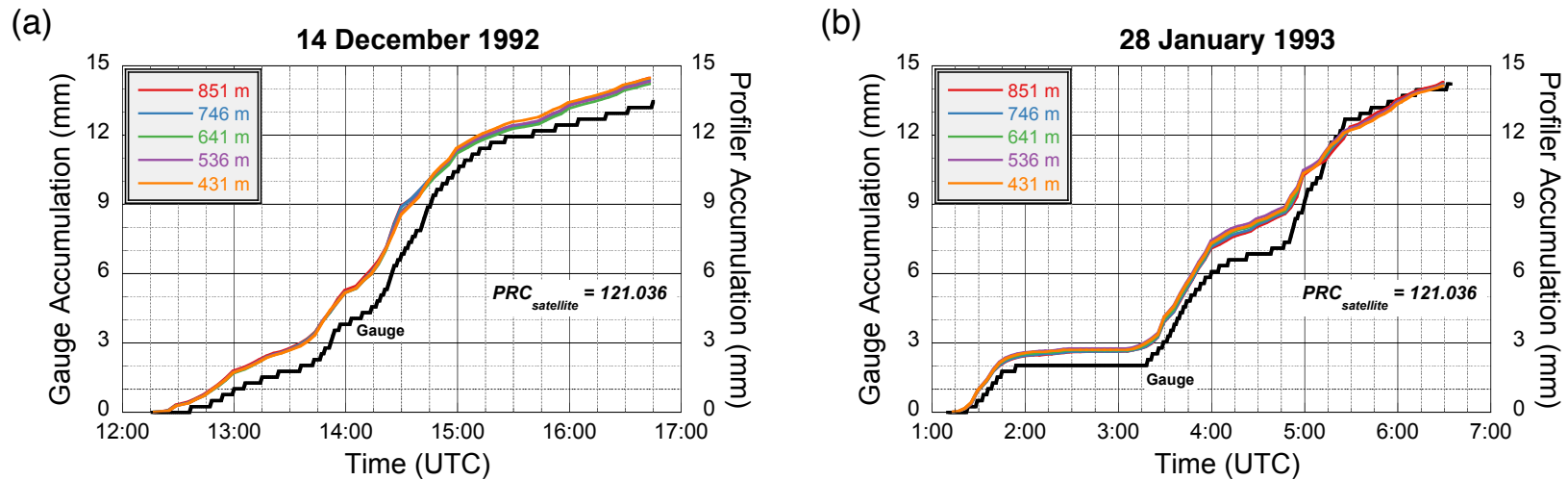


(figure from N. Atkins, Lyndon State College,
<http://apollo.lsc.vsc.edu/classes/remote/index.html>)

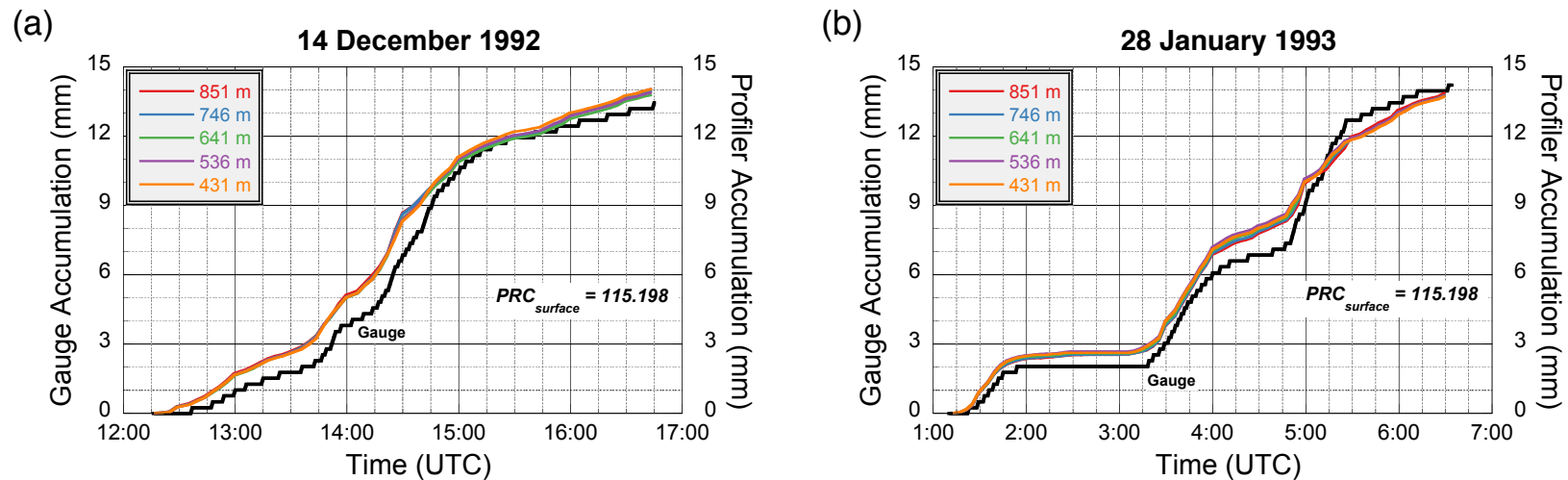
- **Obtained distribution of profiler bright-band reflectivities**
 - July 1992 – August 1994: 10,798 profiles with bright bands
- **Obtained mean TRMM bright-band reflectivities**
 - January 1998 – July 2001: 2,002 bright bands identified

Calibrating against Satellite Reflectivity (cont'd)

- **Estimated rainfall for final satellite-based calibration (+ 7%, – 0.1%)**



- **Estimated rainfall for final surface-based calibration ($\pm 4\%$ of gauge)**



What Do We Do With Two Calibrations?

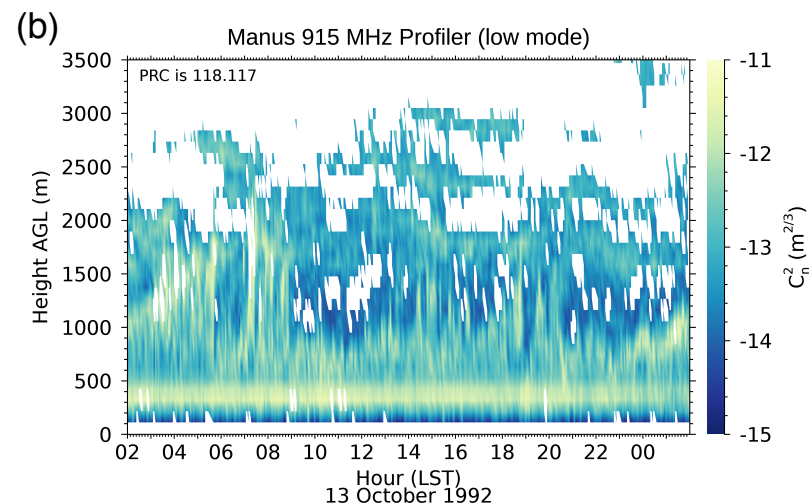
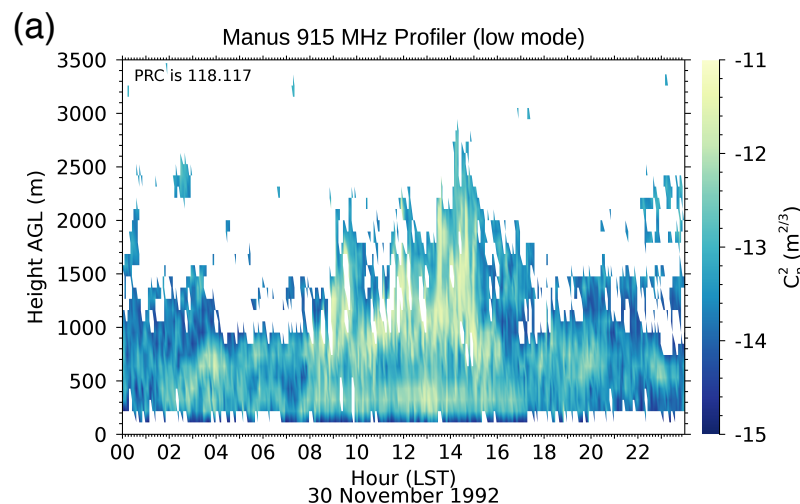
- **Validation and error analysis**

- Satellite-based calibration constant is 5% larger than surface-based
- Accumulations during 2 primary and 2 secondary cases are very similar

- **Average the two; estimated accuracy ± 1.5 dB**

- $\pm 10\%$ error in gauge would change reflectivity ± 0.7 dB
- longterm stability ± 0.4 dB (*Gage et al. 2002, J. Atmos. Oceanic Technol.*)

- **Look at equivalent reflectivity factor Z_e or turbulence (C_n^2)**



What Do You Need to Do This?

- **Surface-based method**

- Trustworthy surface rain measurements
- Careful ID, precipitation type & timing (dwell-by-dwell fall velocity & tip-by-tip rainfall)
- Multiple events

- **Satellite-based method**

- Large numbers of observations from both platforms (many months)
- Consider profiler stability over time (hardware changes; antenna degradation)
- If no temporal overlap, consider how that could matter*

- **Both methods**

- Consider hand editing profiler data (e.g. case studies; removing non-atmospheric returns)
- Beware of extreme echo conditions

* see Poster 465, 32CVC,

“The effect of ENSO and other sources of large-scale variability on observed bright bands over Manus, Papua New Guinea”

Give It a Try!

- **There are years of 915 MHz profiler data**
from numerous locations available ...
to say nothing about S-band wind and precipitation profilers!

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