Poster 465

The Effect of ENSO and Other Sources of Large-Scale Variability on Observed Bright Bands over Manus, Papua New Guinea

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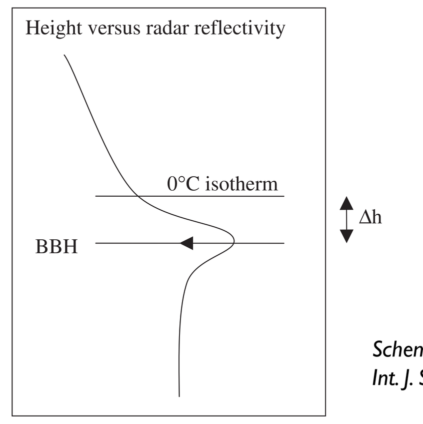
The Big Question

Stratiform rain is characterized by a distinctive radar signature called the bright band (**Fig. A**), a layer of strongly enhanced reflectivity where falling snow is beginning to melt. As part of a study into the possibility of calibrating tropical wind profilers long after they had been removed from the field, we recently found ourselves confronted with the following question:

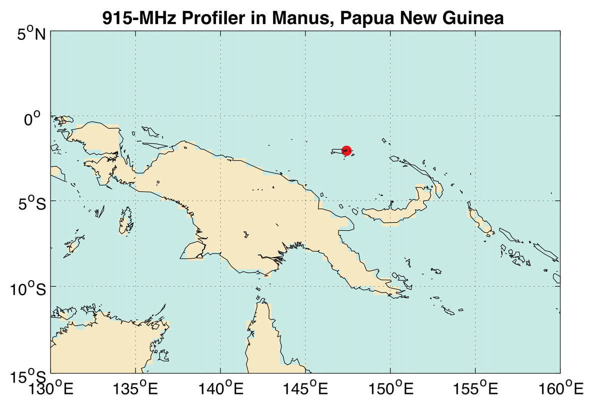
Do the characteristics of observed bright bands over a particular location vary as a function of ENSO?*

*Our actual question wasn't entirely that generic — our calibration focused on the profiler which had been deployed at Manus, Papua New Guinea (**Fig. B**).



Schematic from Thurai et al. (2003, Int. J. Satell. Commun. Network.).

Figure A. A "typical" profile of equivalent reflectivity factor Z_e during stratiform precipitation. The difference between the freezing level and the height of the bright band (BBH) is called the bright-band height depression (Δh).



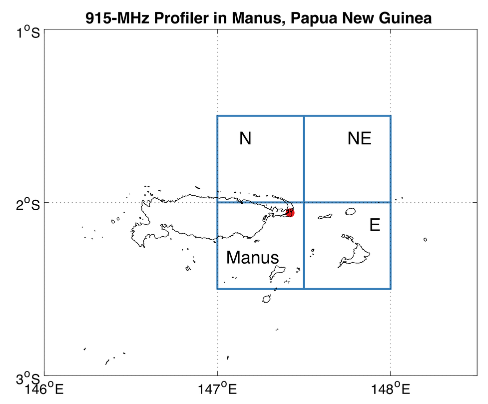


Figure B.

Left: The island of Papua New Guinea and environs. Shading is based on the 0.5° by 0.5° boxes classified as land (tan) or ocean (blue) in the TRMM dataset.

Right: Manus Island and environs, including Los Negros Island where Momote Airport is located (red circle). TRMM gridboxes, all classified as ocean, are outlined in blue.

Acknowledgments

- The TRMM data, which are made publicly available by the National Aeronautics and Space Administration (NASA) and the Japan Aerospace Exploration Agency (JAXA), were obtained in March 2015 from the Precipitation Processing System at http://pps.gsfc.nasa.gov. We are very grateful to Jun Awaka (Tokai University) for assistance in working with them.
- Daily values from the Twentieth Century Reanalysis Project version 2c dataset were extracted using online web tools provided by NOAA/OAR/ESRL/PSD (https://www.esrl.noaa.gov/psd/data/timeseries/daily/). Support for the 20CRv2c dataset is provided by the U.S. Department of Energy, Office of Science Biological and Environmental Research (BER), and by the National Oceanic and Atmospheric Administration Climate Program Office.
- Colors in many figures are based on values from ColorBrewer.org
- We are grateful to Cécile Penland (NOAA/ESRL/Physical Sciences Division) for conversations regarding the statistical analysis of time series.
- This work was supported by grants from NOAA's Climate Program Office to the NOAA/ESRL/Physical Sciences Division.

More Details about this Project

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 Technol.*, revised.

Other References of Interest

Brandes, E. A., and K. Ikeda, 2004: Freezing-level estimation with polarimetric radar. *J. Appl. Meteor.*, **43**, 1541-1553. https://doi.org/10.1175/jam2155.1

Fabry, F., and I. Zawadzki, 1995: Long-term radar observations of the melting layer of precipitation and their interpretation, *J. Atmos. Sci.*, **52**, 838-851.

International Telecommunication Union Radiocommunication Sector (ITU−R), 2001: Recommendation ITU−R P.839−3: Rain height model for prediction methods, 2 pp. [Available online at https://www.itu.int/rec/R-REC-P.839-3-200102-S/en]

Thurai, M., E. Deguchi, T. Iguchi, and K. Okamoto, 2003: Freezing height distribution in the tropics. *Int. J. Satell. Commun. Network.*, **21**, 533-545. https://doi.org/10.1002/sat.768

Data Employed

- **Monthly mean profiler bright band heights & reflectivities, July 1992 – August 1994**, from the 915 MHz wind profiler deployed in the Manus province of Papua New Guinea (2.06°S, 147.42°E). Individual values came from the vertical beam of the "low mode" (105-meter vertical spacing up to 5.2 km); because of the scanning strategy employed, these data occur approximately every 3.8 minutes.
- **Monthly mean TRMM bright band heights and reflectivities, January 1998 – July 2001**, from the TRMM satellite's Ku-band (13.8 GHz) precipitation radar (vertical resolution = 250 m and nadir footprint = 4.3 km). Version 7 values from the 3A25 dataset, which is based on TRMM 2A23 algorithm classifications of radar retrievals into different precipitation types, are available on a 0.5° by 0.5° grid.
- **Monthly mean 20CRv2c freezing level heights, January 1986 – December 2010**, from values linearly interpolated using the Twentieth Century Reanalysis Project version 2c daily timeseries of temperature and geopotential height (600, 550, and 500 hPa) at the 2.0° by 2.0° grid point nearest Manus (2.0°S, 148.0°E).
- **Monthly ONI (Oceanic Niño Index) values, January 1986 – December 2010**, each of which is the 3-month running mean of SST anomalies over the Niño 3.4 region (5°N–5°S, 120°–170°W). Periods during which the ONI is outside the ±0.5 °C threshold for at least 5 consecutive months are considered warm or cold ENSO events.

The Little Questions

Our time series of bright band reflectivities over Manus weren't long enough to enable us to answer this question directly. Since it's well-established that the bright-band occurs somewhat below the 0°C level, we calculated freezing level heights over Manus from the Twentieth Century Reanalysis Project version 2c (20CRv2c). We then explored the "Big Question" indirectly via a series of smaller questions:

Are 20CRv2C freezing levels a reasonable proxy for bright-band heights?

YES. Paired freezing level and bright-heights track each other to some extent (**Fig. C**), although the latter show more high-frequency variability. The bright-band height depressions (**Fig. D**) cover similar ranges as the values for comparable maximum reflectivities. The means from profiler (370 m) and TRMM (373 m) data are larger than Brandes and Ikeda's (2004) linear fit, but comparable to the ~300 m zonal mean difference at 2.5°S found by Thurai et al. (2003) in a comparison of TRMM data with annual mean freezing levels from ITU-R Recommendation P. 839-3.

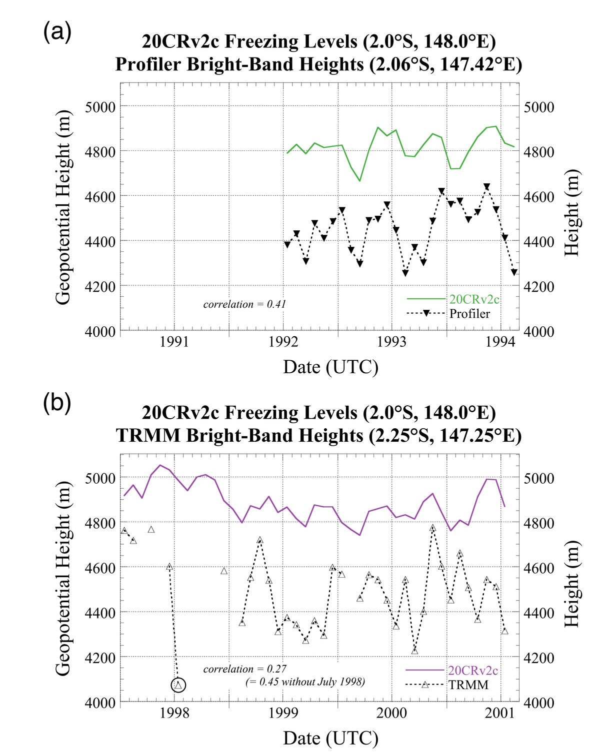


Figure C. 20CRv2c freezing levels over Manus together with bright-band heights from a) the Manus profiler and b) the TRMM grid point over Manus.

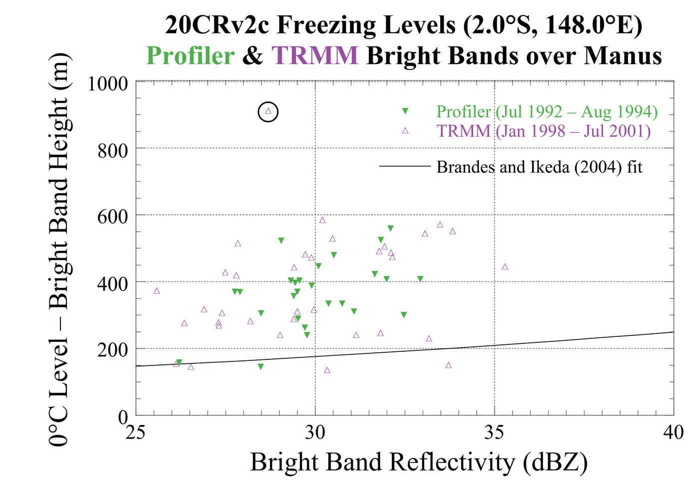


Figure D. Bright-band height depressions over Manus as a function of bright-band reflectivity. Also shown is the line fit by Brandes and Ikeda (2004) to data extracted from observations by Fabry and Zawadzki (1995).

Do freezing levels over Manus show variability related to ENSO?

YES. The 20CRv2c freezing level over Manus has power at ENSO-like timescales (7.1, 3.6, and 2.7 years; **Fig. E**), although the largest power is at 6 and 12 months. The freezing level time series (**Fig. F**) exhibits considerable high-frequency variability as well as visual signs of a lagged relationship with warm and cold ENSO events. The highest positive correlations between the two occur when freezing level lags the ONI by 7 months (r=0.26), which is similar to results from other studies.

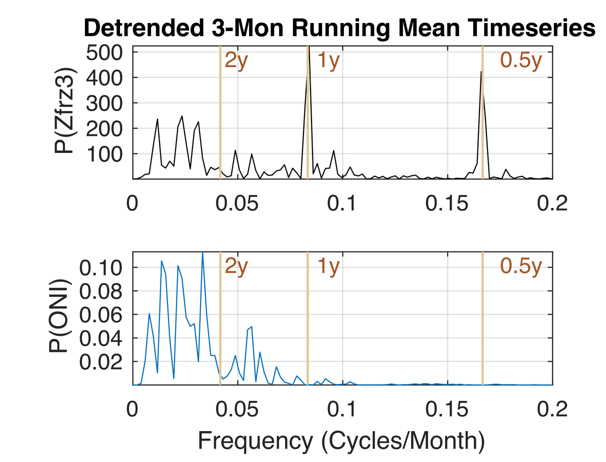


Figure E. Power spectra of detrended monthly timeseries (1986–2010) of the 3-month running mean 20CRv2c freezing level near Manus (top) and the ONI (bottom). Power above 0.2 cycles/month is negligible.

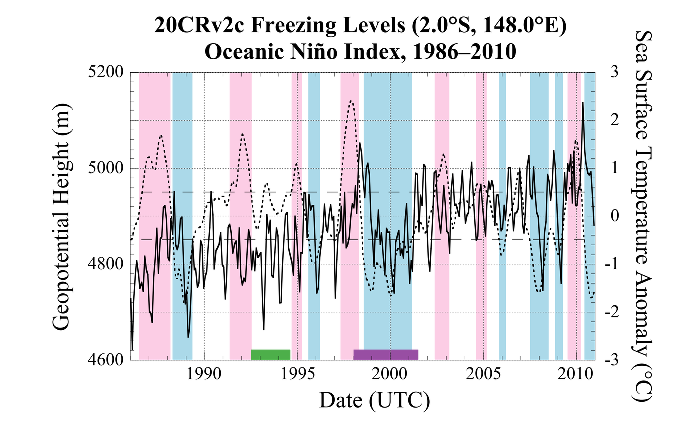


Figure F. 20CRv2c freezing levels over Manus (solid line), 1986–2010. Green and purple bars (bottom axis) highlight profiler and TRMM bright-band data availability. Also plotted are monthly ONI (dotted line) values. Pink and blue shading indicate warm and cold events.

Are bright-band heights over Manus affected by ENSO?

PROBABLY. The freezing heights over Manus do have variability on ENSO, yearly, and half-yearly timescales, and their temporal correlation to the bright-band heights from both the profiler and TRMM suggests that those bright-band heights also have variability on those timescales. (The short duration of the bright band timeseries, and the gaps in the TRMM data, preclude meaningful lagged correlation analysis to confirm this.)

Are bright-band reflectivities over Manus affected by ENSO?

WE THINK NOT. For one thing, we are unaware of any precipitation-related mechanism which would cause the reflectivity of the bright-band to vary with ENSO's phase. While we have no longterm proxy time series for those reflectivities, bright-band heights and the bright-band reflectivities (**Fig. G**) from both the profiler and the TRMM data exhibit only weak negative correlations. From this we infer, but do not prove, that even though the bright-band heights may be affected by ENSO, the bright-band reflectivities appear to be independent of ENSO.

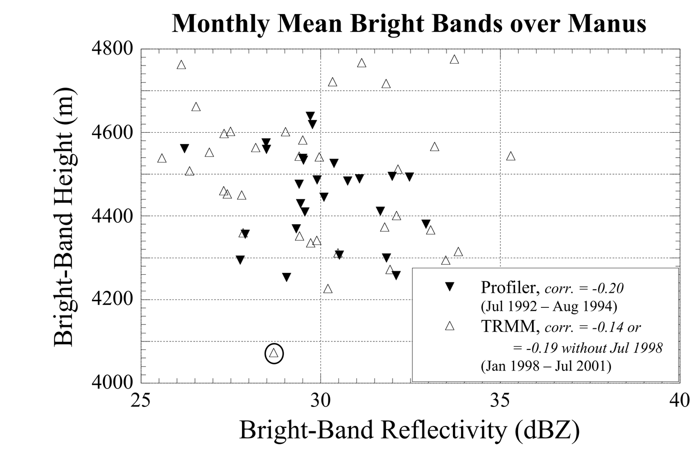


Figure G. Bright-band heights from the Manus profiler and TRMM as a function of bright-band reflectivity.

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