P5.1 USING RADARS AS RADIOMETERS: PROMISES AND PITFALLS

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1. CONCEPT

Many meteorologists studying the atmosphere use radars to obtain information on precipitation and winds from the scattering of microwaves on targets. Others use radiometers to measure the path-integrated vapor and liquid water content from the emission of microwaves in the atmosphere. Although both types of instruments use microwaves to make their measurements, they obtain different and sometimes complementary information by different methods. Yet the hardware present in the two instruments has many similarities, and radars have essentially all the equipment needed to make radiometric measurements (Figs. 1, 2), albeit at different frequencies than radiometers typically function (Fig. 3).

2. RESULTS

Measurements of atmospheric emission have been made with S-band and X-band radars. While considerable qualitative information is available, quantitative interpretation is hindered by the difficulty of obtaining clean noise measurements (Fig. 4), and the generally poorer receiver calibration of radars compared to radiometers, especially in the context of the small signal to be observed. Because in many cases, one can compute the radiometric emission of the atmosphere with much better accuracy than one can measure it, radiometry offers tremendous potential as a method for constantly monitoring the performance of the radar receiver system, especially at longer wavelengths (S- and C-band; Fig. 5). At shorter wavelengths, with minimum modification to the receiver system to better monitor its performance, it is possible to obtain moisture and/or integrated liquid water information by measuring the emissions from the atmosphere blended with the receiver noise. Applications of such measurements span from building radars that can measure the attenuation they suffers from (Fig. 6) to use of the humidity and liquid water measurements in research and data assimilation. See Fabry (2001) for details.

3. REFERENCE

Fabry F., 2001: On the radiometric uses of radars. *J. Atmos. Oceanic Tech.*, submitted.

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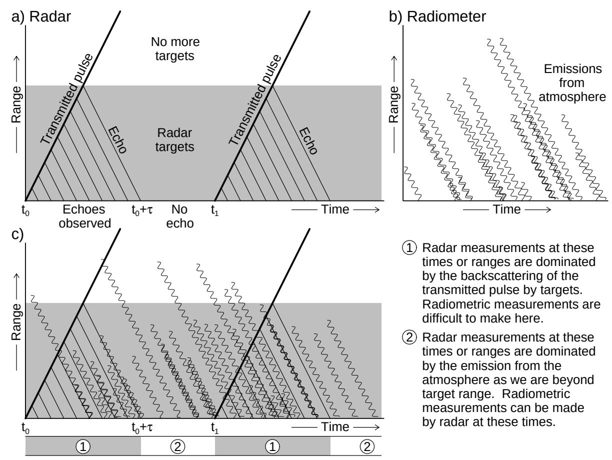

Fig. 1: Illustration of the timing issues related to the use of radars for radiometry. a) Time-Range plot of the propagation of the transmitted radar pulse and of the echoes from weather. Echoes are observed for a certain period, then no echo can be seen until the next pulse is transmitted. b) Time-Range plot of the propagation of atmospheric emission. At any time, emission from all ranges can be observed. c) Combination of the two. Over time periods when echoes are received, they dominate the radar measurement. However, when no more echo is observed, atmospheric emission may be measured by radar.

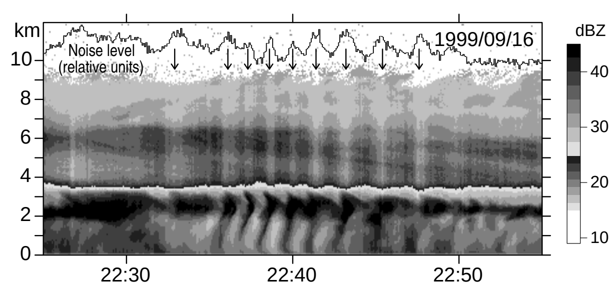

Fig. 2: Height-time section of reflectivity collected by a vertically pointing radar when the remnants of hurricane Floyd passed over Montreal. Several streaks of precipitation can be seen between 22:35 and 22:45 UTC. Over these streaks, bands of enhanced attenuation indicated by arrows leave their mark by weakening the snow echoes. Plotted above is the measured noise level obtained above the echoes. Noise level, a combination of internal noise and atmospheric emission intensity, has local maxima that coincide with the most severe attenuation; microwave emissions from attenuating media can hence be measured by radar.

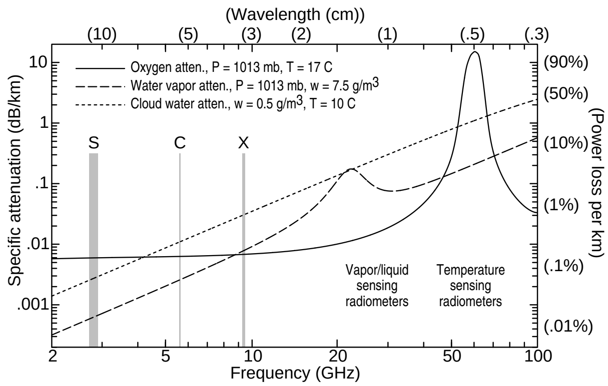

Fig. 3: Specific attenuation as a function of frequency for oxygen (solid line), water vapor (dashed line), and liquid water (dotted line) under specified meteorological conditions. At the indicated radar frequencies, microwave attenuation/emission is one to three orders of magnitude smaller than for radiometers.

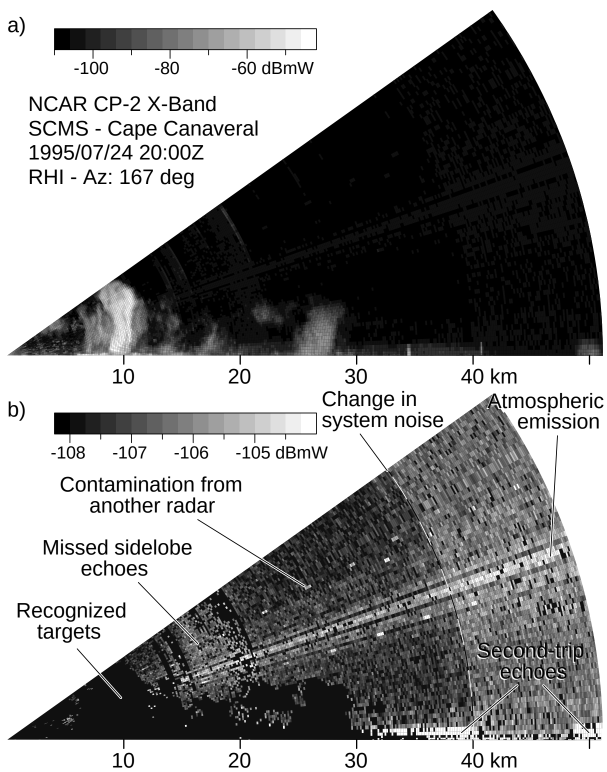

Fig. 4: RHIs of received power measured by the National Center for Atmospheric Research CP-2 radar at X-band near Cape Canaveral, Florida, in summer 1995. a) The RHI shows the presence of a strong cell near 10 km range and of other echoes. b) The same RHI is reproduced, but with emphasis on the low power measurements. Targets whose coherence exceeded a given threshold were recognized as such and blacked out. The remaining pixels are identified as noise, and would potentially be used to measure atmospheric emission. However, many of these pixels are contaminated and need to be avoided in order to get a proper measurement of noise power.

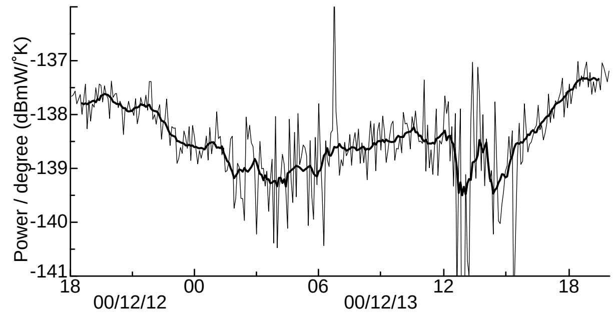

Fig. 5: Change in measured noise power associated with a change of 1 K in brightness temperature as a function of time for a strong winter front case. For a given change in brightness temperature, one should expect a time-independent change in noise power if receiver calibration remains constant; time variations in that number imply changes in receiver sensitivity. The fat line is a one-hour running mean of these values. Changes of 1 dB in receiver sensitivity can be observed during the period associated with large changes in temperature in the receiver room (results obtained between 12Z and 15Z are questionable).

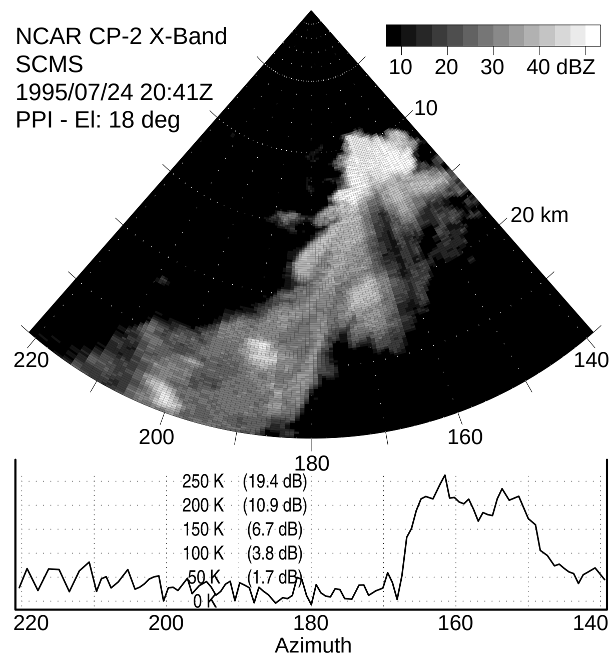

Fig. 6: Example of the possible measurement of radar attenuation by radiometry. Top: Reflectivity PPI at an elevation of 18º taken by the NCAR CP-2 X-band radar in convective rain. Considerable shadows caused by attenuation can be observed in the radar data, especially near the 160º azimuth, caused by a strong cell 12 km away from the radar. Bottom: Brightness temperature estimated from the measured noise power as a function of azimuth. Next to the brightness temperature labels, the associated two-way attenuation has been computed assuming that all the attenuation occurred near 12 km range (3.5-4 km altitude) where the temperature was around 280 K.