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Relative and absolute calibration of polarimetric weather radar receivers using the Solar flux

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The use of extraterrestrial sources of radio noise as calibration aid has been reported in the literature since the 60s, aiming especially at evaluating the performance of radio telescopes. In 1976, Whiton et al. [1] discussed for the first time the calibration of weather radar receivers using the Sun. The idea was implemented in the late 70s by Frush and Lewis [2] and preliminary presented in 1984. In 1989, Pratte and Ferraro [3] presented the first quantitative comparison between S-band single polarization radar-derived solar flux values and the accurate reference measurements acquired by the Dominion Radio Astrophysical Observatory (DRAO). To obtain best results the radar has to be off-line during the tracking of the Sun in order to have the antenna beam axis pointing at the center of the Sun. In the 90s, using the above-cited semi-automated technique [3] a radar operator could perform the data acquisition phase of the calibration in twenty minutes. With modern fully digital receivers and radar signal processor, the acquisition time has been reduced by an order of magnitude: at MeteoSwiss for instance, we have implemented a Sun tracking procedure that lasts less than two minutes. If overall losses along the receiver path, bandwidth and antenna equivalent area are known, then one can transform the received power from the Sun into incident spectral irradiance, which is often called Solar flux and measured in W/(m^2 Hz). Very recently, the method has been implemented on a polarimetric, fast 3D scanning, Doppler X-band radar on wheel. Obviously, the transformation of DRAO reference values from S-band to X-band implies even larger uncertainties than from S-band to C-band. Such radar estimates can be quantitatively evaluated in three ways: A) mutual agreement between radar Horizontal (H) and Vertical (V) polarization retrieved values; B) relative agreement between radar H (or V) and the DRAO reference value; C) absolute agreement between radar H (or V) and the DRAO reference value.

For operational weather services, the Sun-tracking method has the disadvantage that the radar has to be off-line during the sun raster scans (typically three or five observations to derive one daily value). A valid alternative is the operational method (by Huuskonen, Holleman et alia), which analyzes Sun signals acquired during operational scan and stored in polar volume data; for retrieving a daily value of solar spectral power, several tens of radar reflectivity values are fitted using the 5-parameter model extensively described in [4]. Once that the 5 parameters are derived (for instance by means of the least squares method), the peak solar power that the radar would have received if the beam had hit the Sun center, can be estimated. Indeed, this is the “core” of the method; it deals with the convolution between the antenna radiation pattern and the solar disk (during operational scans, the antenna beam axis never hits the center of the solar disk!) The method has been successfully implemented for determining and monitoring the electromagnetic antenna pointing [4], assessing the receiver stability [5] and monitoring the differential reflectivity offset [6] during several months of 2008, which is a period of quiet solar flux activity. The method proved to be successful also during the currently active Sun period [7]: the ten C-band radar receivers analyzed in 2014 in Finland, Switzerland and the Netherlands were able to capture and describe the monthly variability of the Sun microwave signal [8]. Very recently, a further refinement of the method with focus on the monitoring of weather radar differential reflectivity bias has been developed [9] and applied to several radars in Finland.

In the extended abstract and at the conference we will present several examples, figures and results regarding both the online and the offline [10] method.

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