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Development of novel ground-based microwave radiometer for earth science -results of the first measurements-

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Abstract

We have started to develop a next-generation microwave radiometer to be used in millimeter-wave spectroscopy for the high-resolution and high-precision monitoring of water vapor behavior. The new radiometer will be suitable for not only space geodetic techniques such as VLBI and GNSS, but also field measurements such as monitoring volcanic activities and cumulonimbus cloud generation.

The planned front-end system for our new microwave radiometer has a wide bandwidth feed of 20–60 GHz for measuring two frequency bands of 20-30 GHz (H_2O) and 50-60 GHz (O_2) as shown in Figure 1. A signal from the feed is separated into two linear orthogonal polarized signals from the feed, one is in the 20–30 GHz feed and the other in the 50–60 GHz feed, using an orthomode transducer (OMT) as shown in Figure 2. The wideband feed, OMT, and the LNA for each signal will be cooled at 77 K using a Stirling cryocooler to improve signal-to-noise ratio. We have assembled a room temperature 20–30 GHz receiver without the cooling system until the middle of 2019 as a first step of our development (see Figure 2). We have implemented the new receiver into the 3.7 m dish ((Figure 3 and Figure 4) at Okinawa Electromagnetic Technology Center, National Institute of Information and Communications Technology (NICT) and we have carried out first measurements using it for validation test on October, 2019 (Figure 5). A quicklook data obtained by the new receiver shows good power signals for the expected receiving band of 18-28 GHz as shown in Figure 6 and Figure 7. We are now developing an another receiver for higher band 50-60 GHz and we are going to implement the second one into the new system until the end of this fiscal year.

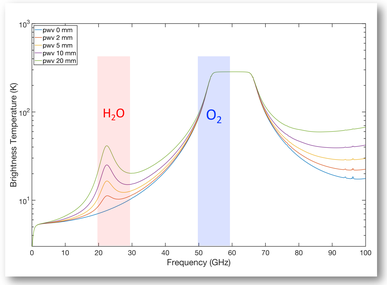

Figure 1: Effective temperature of atmospheric radiation as a function of observed frequency. This plot is obtained using the *am model* [3].

Figure 2: Schematic block diagram of a planned front-end system for the next-generation microwave radiometer.

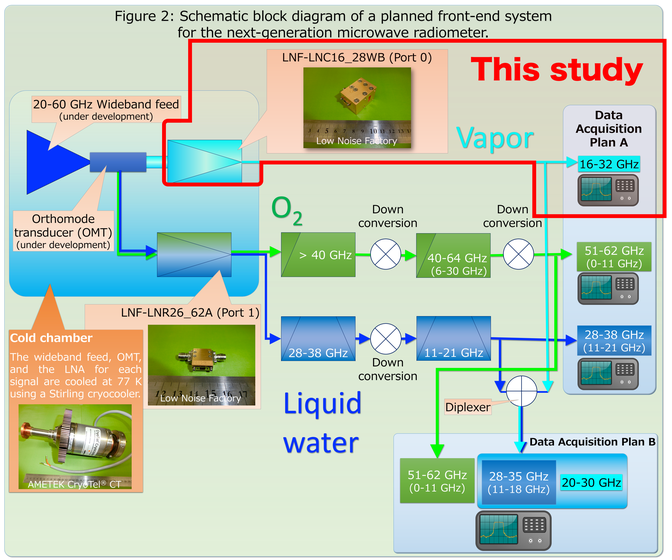

Figure 3: Location of NICT Okinawa Electromagnetic Technology Center (Upper). The Okinawa 3.7 m dish, for validation measurements using a new front-end as shown in Figure 2 (right-upper) and cumulonimbus cloud nearby the dish (right-lower).

The first test measurements at Okinawa Electromagnetic Technology Center , NICT.

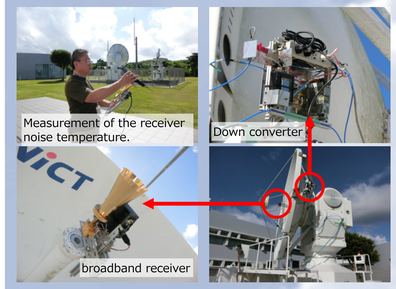

Figure 4: Installation of the new receiver on the 3.7 m dish.

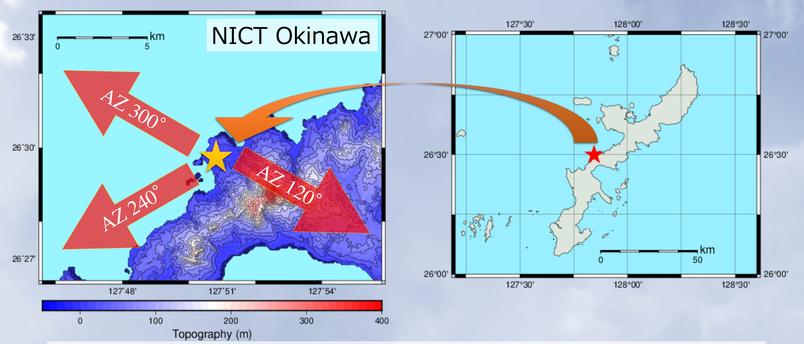

Figure 5: Site location of the NICT 3.7 m dish. Antenna directions for the validation measurements are shown in this Figure.

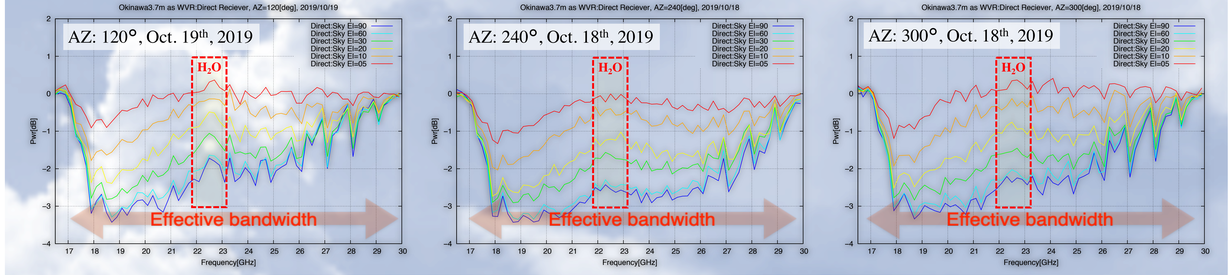

Figure 6: Variation of signal power with frequency at different elevation angles.

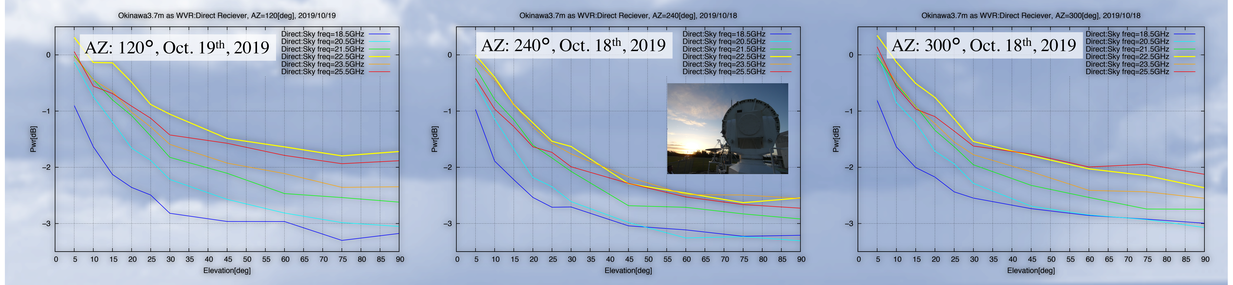

Figure 7: Signal power as a function of elevation angle for different frequencies.

Outlook

We are now developing an orthomode transducer (OMT) to separated into two linear orthogonal polarized signals from the wide-band feed. The signal is divided into a bandwidth of 20–30 GHz (H_2O) and one of 50–60 GHz (O_2) using the OMT. The wide-band feed, OMT, and the LNA for each signal will be cooled at 77 K using a Stirling cryocooler to improve signal-to-noise ratio. The development of a new front-end module will be completed in the middle of 2020, and we are planning to perform the validation experiments using the new receiver system in this fiscal year.

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