Development of Software-Defined Multi-Channel Receiver System for the Equatorial Atmosphere Radar (EAR)

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Equatorial atmosphere is typically associated with the generation of most active convective motions which caused by absorption of strong solar radiations thus significantly affecting global atmospheric changes. However, the coupling processes in the equatorial atmosphere which incorporate hierarchical structure horizontally and vertically are still under debate specifically due to the sparseness of the observational data in the region. Furthermore, all the processes involved in the different layers of atmosphere were typically studied independently without a unified viewpoint which leads to a difficulty to identify the proper mechanism involved in the atmospheric changes and fluctuations.

Equatorial Atmosphere Radar (EAR) was established in June 2001 by the collaboration between Research Institute for Sustainable Humanosphere (RISH), Kyoto University and Indonesian National Institute of Aeronautics and Space (LAPAN) to improve the understanding of the equatorial atmospheric and its dynamical and electrodynamical coupling processes. EAR is a VHF Doppler radar operated at 47 MHz with an active phased-array antenna system and located at the equator at Kototabang, West Sumatra, Indonesia (0.20oS, 100.32oE, 865 m above sea level). It uses a quasi-circular antenna array with a diameter of approximately 110 m which consists of 560 three-element Yagi antennas. The maximum output power of the EAR is 100 kW.

Currently, the EAR has only a single receiving channel, and it still manages to produce interesting observations output regarding the atmospheric turbulence. Furthermore, with the availability of Radio Acoustic Sounding System (RASS) at the EAR site, it enables the observations of vertical profile of temperature thus make it possible to observe turbulence occurrence through continuous observations. The rapid development of multi-channel receiver system in most radar system allows for the implementation of more sophisticated observation technique such as spaced-antenna (SA) and spatial imaging observations. Here, we present the initial development of multi-channel receiver system for the EAR using general-purpose software-defined radio receivers.

The multi-channel digital receiver system will be developed using the combination of Universal Software Radio Peripheral 2/N210 (USRP2/N210) series and GNU Radio which allow the implementation of sophisticated software-defined radar receiver, yet at lower development cost compared to conventional radar hardware. The receivers are synchronized using 10 MHz reference clock and 1 pulse per second (PPS) signal. Signal processing such as filtering, range gating, and coherent integration will be performed in real time utilizing a personal computer and GNU Radio software and the data produced will be stored in an external hard disk for post processing.