URSI-RCRS 2024, ARIES/GEHU, Bhimtal, India, 22 - 25 October, 2024

Azimuth echo variation in the troposphere and lower stratosphere from multiple Doppler beams and vertical in-beam spatial interferometry: First results from Haringhata 53 MHz ST radar

Siddarth Shankar Das[1], N. Poddar[1,2], M. V. Ratnam[3], A. Paul[4], V. Venugopal[1,2], P. Nandakumar[4]

[1]Space Physics Laboratory, Vikram Sarabhai Space Centre, ISRO, Thiruvananthapuram
[2]Department of Physics, University of Kerala, Thiruvananthapuram
[3]National Atmospheric Research Laboratory, DOS, Gadanki
[4]Institute of Radio Physics and Electronics, University of Calcutta, Kolkata

Corresponding author: siddarth_das@vssc.gov.in & dassiddhu@yahoo.com

Abstract. Very-high frequency (VHF) radar echoes are known to be aspect sensitive in general, which is the manifestation of either thin stable layer providing sharp refractive index gradient or shear driven steep layer structures. Strong thermal gradient in the vicinity of tropopause (14-20 km) acts like a perfect reflector and is found to be highly aspect sensitive to these VHF radar echoes. Earlier it was observed with a VHF radar ranging from 49-53 MHz (205-206 MHz) that the echo signal strength decreases rapidly up to 10-12 degree off-zenith angle with an average rate of about 1.2 dB/degree (0.75 dB/degree) and at about 0.6 dB/degree (0.9 dB/degree) beyond it. These aspect sensitive characteristics are attributed to Fresnel reflection/ scattering from sharp gradients in the radio refractive index. India has a network of Stratosphere-Troposphere (ST) / Mesosphere-Stratosphere-Troposphere (MST) radars located at Gadanki, Cochin, Nainital, Guwahati, Haringhata, Sriharikota, and Kalpakkam. Azimuth variation of VHF radar echo power has already been reported in the multiple Doppler beam experiments at Gadanki and Cochin. A state-of-the-art, newly indigenously developed, high power ST radar operating at 53 MHz at Haringhata (22.94°N; 88.51°E) is a Pulse-Doppler radar with a peak power of 950 kW and peak power aperture product of 3 x10^8 Wm^2. There are 475 antennas (3-elements Yagi Uda) arranged in a near circular array with a diameter of 95 m and inter-element spacing of 0.7λ. The antenna array has been configured in the form of 25 subarrays and each subarray having 19 elements. Each antenna is fed with a single transmit-receive (TR) module of ~2 kW, which make the radar to work as fully active phase system. Using the full capability of Haringhata ST-radar, an experimental campaign was conducted by operating the radar in four different modes. The aim of this experimental campaign is to (1) compare the wind derived from Doppler beam with spatial interferometry and its validation with radiosonde observations, (2) characterise aspect sensitivity using multiple Doppler beams, and (3) 3-dimensional imaging using multiple receivers. Mode-1 and Mode-2 are operated in multiple Doppler beams, whereas Mode-3 and Mode-4 are operated in vertical in-beam spatial interferometer. Mode-1 has 5 zenith beams in east, west, zenith, north, south with 10-degree off-zenith to derive winds and turbulence. Mode-2 provides full azimuthal beam steering (full volume-scanning) which is used to study the 3-dimensional structure. Mode-3 experiment is used to derive wind in the interferometry mode in which the full-array of 475 elements are used for transmission but only 3 receivers (each has 19 antennas) configured in isosceles triangle are used. In mode-4, the receivers are configured with 19-channels by transmitting with full-array. Initial results show that the wind derived from both the Doppler beam (mode-1) and space antenna (mode-2) methods compared well with the radiosonde observations. Further the presence of multiple layer structure is observed in the radar observations, which indicate the presence of temperature sheets in the upper troposphere and lower stratosphere (mode-1). Observations show high aspect sensitive radar echoes that correspond to the enhanced stability and wind shear (mode-2). Aspect sensitivity (aspect angle and horizontal correlation length) for different zenith and azimuth beam combinations are also estimated. It is found that there may be an underestimation of about 2-5 % in wind velocity measurements at altitudes where aspect sensitivity is high with the underestimation being higher for low off-zenith beam angles. Using mode-3, a radar imaging experiment is demonstrated. The detailed results will be presented and discussed in the upcoming conference.