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L& S Band Airborne SAR Data Products Calibration

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ISRO in collaboration with JPL, NASA is developing a Dual Frequency Synthetic Aperture Radar-NISAR (NASA-ISRO Synthetic Aperture Radar) in L and S Band frequencies. As a pre-cursor to NISAR, Space Applications Centre (SAC-ISRO) has developed a L and S Band-Airborne SAR (LS-ASAR) which is crucial in preparing the scientific community for optimum utilization of NISAR data. With the capabilities of Quad, Hybrid and Dual Polarization modes in both L, S band and Look Angle operations of 37^0, 51^0 and 64^0 ;LS-ASAR provides invaluable data for various scientific applications. The effective use of polarimetric SAR data by science applications requires data to have accurate radiometric, polarimetric and geometric calibration. This paper presents details of these calibration aspects for LS-ASAR data products.

LS-ASAR processor incorporates robust motion compensation taking into account along track and cross track displacement errors. Lab measured antenna patterns have been used for Antenna pattern correction of processed SAR images. These corrected SAR images have to be calibrated for: the co-polarization channel imbalance (f), cross-polarization channel imbalance (g), phase errors incurred while transmitting ($\phi_{t,\ j}$) and receiving ($\phi_{r,\ j}$) polarization ($j=h/v$). LS-ASAR corner Reflector acquisitions (site: Desalpar, Gujarat; IMGEOS, Hyderabad) of trihedral and dihedral point targets and distributed target acquisitions have been used for radiometric and polarimetric-phase calibration. As mentioned in [1] for quad polarization data, first the radiometric and phase calibration have been performed neglecting crosstalk and thereafter cross-talk calibration has been applied. Equation (1) [1] is the basis for applying the calibration parameters which are estimated from interpolated corner reflector response peaks ($A, f, \phi_t + \phi_r$) and by coherent average of distributed targets like forests ($g, \phi_t - \phi_r$).

$$S' = A\begin{bmatrix} s_{vv} f^2 e^{i\,(\emptyset_t + \emptyset_r)} & s_{vh} (\frac{f}{g})\, e^{i\,(\emptyset_r)} \\ s_{hv} f g e^{i\,(\emptyset_t)} & s_{hh} \end{bmatrix} \qquad (1)$$

where, *S' is the measured scattering matrix, A the absolute calibration constant,* $\phi_t = \phi_{t,v} - \phi_{t,h}$; $\phi_r = \phi_{r,v} - \phi_{r,h}$

Self-Calibrating nature of circular polarization [2] data was utilized for its calibration. RCS and relative phase was analyzed for corner reflectors and several distributed targets to derive the calibrations parameters ($A, f, \phi_t + \phi_r$) for circular polarization data. The consistency and applicability of calibration parameters was validated by subjecting calibrated data to polarimetric decompositions for quad polarization (e.g. *Pauli, Freeman etc.*) and Hybrid polarization *(m-delta, m-chi*) data. Relative phase between H and V receive chains for the targets specified as single bounce, double bounce and volumetric in polarimetric decompositions was analyzed for their accuracy to establish the phase calibration.

Integrated GPS INS(IGIS) system on-board senses aircraft motion. This data along with Terrain Digital Elevation Model –DEM (CARTO-DEM) have been used for generating geometrically calibrated LS-ASAR data products. GPS co-ordinates for corner reflectors were used to validate Geometric calibration of LS-ASAR data products.

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2. R. Keith Raney, "Hybrid-Polarity SAR Architecture", *IEEE* Trans. Geosci. Remote Sens. vol. 45 no. 11, Nov. 2007.